What does culture do to our brains? The Theuth effect: cultural adversity and cultural felicity

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Summary

My aim in this article is to present a new field of research, namely the Developmental Valence of Cultural Matrices (DVoCM) studies. The topic is what in cultural matrices limits (cultural adversity) or extends (cultural felicity) the optimal development of human cognitive abilities – a phenomenon termed Theuth effect. Cognitive abilities are broadly defined as information processing, whatever the information processing mode: by sensation and perception (including sensorimotor aptitudes), by emotions or by high-level mental abilities. In the first part, I provide several examples of the powerful effects of cultural matrices on brain structures and human cognitive abilities, I outline recent attempts of synthesizing them in terms of methodological approaches or theories, and I point out some of the major limits of these approaches. In the second part, I define the objectives of the DVoCM studies, and I describe the methods to be developed in order to promote research on the Theuth effect. I conclude arguing that the evaluation of the developmental valence of cultural matrices would enrich our knowledge of cultural diversity, and would be a valuable indicator of the overall wellbeing of human life forms.

> "Consider the possibility that any man could, if he were so inclined, be the sculptor of his own brain, and that even the least gifted may, like the poorest land that

has been well cultivated and fertilized, produce an abundant harvest" (Ramón y Cajal 1999: xv-xvi).

1. INTRODUCTION

In 2004, the chairman of TF1, a major French television channel, declared: "What we sell to Coca-Cola is available human brain time." He thus highlighted that the vocation of his medium was to offer advertising to the receptive brains of spectators. This is only an anecdote that, beyond any intention to create a straw man, is a useful rhetorical way of introducing the main issue that underlies this article: *What does culture do to our brains?* More specifically, my main question is: what do *cultural matrices* do to our brains, a cultural matrix being defined as a generative socio-physical configuration of a deep sharing (i.e. behavior and representations) between individuals?

This is an old question. In *Phaedrus* (274-275b), the famous god Theuth, inventor of many arts, presents the invention of writing to king Thamus as a means for giving Egyptians "better memories." Thamus immediately warns Theuth: "for this discovery of yours will create forgetfulness in the learners' souls, because they will not use their memories". Human beings, Thamus added, will learn an abundance of information that will induce them to believe in their competence in many domains, but they will have "the show of wisdom without the reality". In my own words, the Thamus' question becomes: what does a cultural matrix do to the productions of our brains, i.e. to our cognitive abilities, broadly defined as information processing, whatever the information processing mode: by sensation and perception (including sensorimotor aptitudes), by emotions or by high-level mental abilities[1]?

This is a relevant and currently debated question. Because of its amazing plasticity, and because of the highly impressive power of human culture (Greenfeld 2013), our brain is culture-dependent. Consequently, cultural psychology, cultural and social neurosciences, and even human social genomics are booming disciplines, which are increasingly interested in the developmental effects of culture on brain and cognition (Henrich 2016; Thompson *et al.* 2016). Yet, unlike in Plato (who, of course, was wrong about the invention of writing), the issue of the developmental valence of cultural matrices –from here "DVoCM" - is presently not addressed head-on and systematically.

I address this issue in this article. First, considering the huge power of human culture and the immense plasticity of our brain, I show that DVoCM influences our cognitive skills for better or for worse. I term this influence the Theuth effect, referring to Plato's aforementioned text. Positive influence is termed Theuth effect+ (from here on "T+"), and negative influence Theuth effect- (from here on "T-"). There will be T+, or cultural felicity, when DVoCM induces an added value compared to the cognitive potential of individuals at birth. There will be T-, or cultural adversity, when DVoCM induces a loss compared to the cognitive potential of individuals at birth. Obviously, one can imagine all intermediate solutions on the T-/T+ axis. Secondly, I hypothesize that it is possible to outline a theoretical framework and a methodology to identify and assess this DVoCM in a comparative perspective. Finally, I argue that the evaluation of this DVoCM would enrich our knowledge of cultural diversity, and would be a valuable indicator of the overall wellbeing of human life forms. Put simply, this article aims to understand when, why and how we have the Theuth effect, what is the DVoCM inducing this effect, and to what extent it can be important for human societies to assess this DVoCM.

2. CULTURE IS HUMAN NATURE

2.1. Human Beings Are Immersed In Culture

Culture is a natural phenomenon not specific to humans. Even if it is difficult to sort the genetic

[1] For the sake of simplicity, I will use the terms "cognitive abilities" or "cognitive skills" to include all of these information processing modes.

from the cultural (Langergraber *et al.* 2010), cultural or protocultural forms have been documented among apes (Boesch & Tomasello 1998; Breuer *et al.* 2005; Hohmann & Fruth 2003; McGrew 2010; McGrew *et al.* 2001; Mercader *et al.* 2007; Morgan & Abwe 2006; Sapolsky & Share 2004; van Schaik *et al.* 2003; Whiten 2001; Whiten *et al.* 1999) and monkeys (Huffman 1984; McGrew 1998; Visalberghi *et al.* 2013), and exist among species which are much more distant from our species than non-human primates (Auersperg *et al.* 2014; Fehér *et al.* 2009; Laland & Reader 1999; Noad *et al.* 2000). However, human culture is really unique because of its prevalence, its diversity, its complexity, its cumulative evolution, its inclination towards innovation, its various means of transmission (vertical, horizontal, oblique, from one to several, from several to one, etc.), its manifold forms of cooperation (Candau 2012; Henrich & Henrich 2007; Nowak & Highfield 2011; Tomasello 2009) including regular cooperation with nonrelatives (unlike other animals), the fact that it is massively embedded in the environment, notably in social institutions, and in a multitude of artefacts (Clark 2008) and of what I called "sociotransmitters" (Candau 2005). Human culture is unique because of *the range and intensity* of its power. On the one hand (*range*), cultural expectations invade more or less every aspect of daily life. On the other hand (*intensity*), they can impact more or less profoundly our everyday life. Let us take the example of religion. Cultural religious expectations potentially encompass every aspect of the life of people from birth to death. Thus, their range is almost limitless compared with, for example, aesthetic codes which only concern some specific aspects of our existence. Besides, in some societies these cultural expectations are more diffuse (weak intensity) than in others (strong intensity), where, in extreme cases, they are absolutely inescapable (maximal intensity). For example, in French society as a whole (of course, a simplistic view), cultural religious expectations have a medium range and a weak intensity. In contrast, they have a wide range and a strong intensity in Iranian society. In a religious sect or during a spiritual possession rite (Halloy 2015), the intensity is maximal. Therefore, cultural expectations can be variable in range and intensity but, from a more general anthropological perspective, among human beings culture has a large range and acts in a very intense way, in the sense that it is everywhere, at every moment. Human nature is to be cultural. Our species is "wired for culture" (Pagel 2012). Thus, culture pervades human lives, from the genome and epigenome (for an overview, see Laland *et al.* 2010) to behavior. This includes the body (which the brain is part of) and its performances, including cognitive abilities.

2.1.1 The natural human capacity to culturally modify human nature

A few years ago, the term 'anthropocene' was coined by Nobel Prize winning scientist Paul Crutzen (2000) to describe the epoch in the Earth's history, which started in the late 18th century, when the activities of humans first began to have significant effects on nature. Crutzen thought mainly about Earth's climate and ecosystems (Jones 2011), but, in my view, the term can also indicate the natural capacity of human culture to modify human nature. Indeed, human lifestyles can act on the genotype. We considered for a long time that the relationship between genes and culture was one-way, that it is to say that only genes could have an effect on culture; we know today that culture can keep genes on a leash! Both low levels of genetic diversity and genetic differentiation in modern humans are not only the effects of natural selection (Barreiro *et al.* 2008) but are also the effects of culture. On the one hand, by limiting their mate choices to individuals of a similar culture, our ancestors possibly reduced the spread of new mutations across many groups (Premo & Hublin 2009). On the other hand, a correlation between linguistic borders and alleles frequency, which does not always correspond to physical boundaries (such as a mountain or a channel), has been observed in Europe (Barbujani & Sokal 1990; Pagel & Mace 2004), in Indonesia (Lansing *et al.* 2007), in South Amerindian populations (Hünemeier *et al.* 2012), etc. In this case, it is the practice of different languages which induces or supports sharp changes in gene frequencies. Another astonishing example of the influence of human lifestyles on genome diversity is the comparison of mtDNA and Y-chromosome variation in matrilocal and patrilocal groups. It shows a correlation between genetic diversity and residence pattern, supporting the role of sex-specific migration in influencing human genetic variation. The result is that women are genetically less structured than men (Oota *et al.* 2001; Ségurel *et al.* 2008) because of the predominance of both patrilocality and social organization of patrilineal populations.

Thanks to the emerging field of social genomics (Cole 2009), and to research in gene-culture co-evolution (Feldman & Laland 1996; O'Brien & Laland 2012), we have many examples where culture can act on the genome, and thereby alter human gene expression. There is genome-wide evidence for positive selection due to changes in diet, and subsistence (Chiaroni *et al.* 2009; Hancock *et al.* 2010). For instance, among human beings, the ability to digest milk declines sharply after infancy - half of modern humans cannot digest it -, but for most European and Euro-American people, and for some populations in Africa (Tishkoff *et al.* 2007), lactose (the main carbohydrate present in milk) is well tolerated. For over 8.000 years, these lactose-tolerant human societies exploited dairy breeds (Beja-Pereira *et al.* 2003; Check 2006; Feldman & Cavalli-Sforza 1989; Flatz 1987; Gibbons 2006; Holden & Mace 1997). In opposition to the "reverse cause hypothesis," whereby dairying would have been adopted in populations with preadaptive high lactase persistence allele frequencies (a trait conferring the ability to digest the milk sugar lactose in adults), findings provided mounting evidence for the "culture-historical hypothesis" (Burger 2007), whereby lactase persistence alleles were rare until the advent of dairying early in the Neolithic age, but then rose rapidly in frequency under a selective pressure resulting from the adoption of cultural traits—namely animal domestication and adult milk consumption. Another example is the tolerance to starchy food. Populations with high-starch diets have, on average, more salivary amylase gene (AMY1), the enzyme responsible for starch hydrolysis, than populations with traditionally low-starch diets (Perry *et al.* 2007). I give two final related examples. The use of cereals as the staple diet by some populations is strongly correlated with higher frequencies of *PRLP2* gene variant than by populations who have other diets (Hancock *et al.* 2010). Amongst Japanese people, consumption of marine microorganisms that live on seaweed – which contribute strongly to the daily diet in Japan - have introduced useful genes into their intestinal microbiome, which are absent among North American individuals (Heheman *et al.* 2010).

Researchers scrutinizing the genome unveil dramatic evidence of socioenvironmental influences, some of them concluding that regular changes in human cultures and ecologies linked with human demographic growth are hastening human evolution (Cochran & Harpending 2009; Gibbons 2010; Hawks *et al.* 2007). For instance, to inhabit in hypoxic conditions is a cultural behavior which have effects on our genes. In just a few thousand years, Andean, Deedu (DU) Mongolians, Ethiopian Amhara, and Tibetan populations (in this last case, likely by introgression of Denisovan-like DNA: Huerta-Sanchez *et al.* 2014) living at high altitude have adapted to hypoxia differently, with convergent evolution affecting different genes from the same pathway (Alkorta-Aranburu *et al.* 2012; Huerta-Sánchez *et al.* 2013; Simonson *et al.* 2010; Xing et al. 2013; Yi *et al.* 2010). The sequenced ancient DNA from 230 people who lived 3000 to 8500 years ago in Eurasia is another example of gene-culture coevolution. According to this research, the transition to farming favored genes to digest fats, as well as immune genes that protected against infectious diseases, such as tuberculosis and leprosy (Mathieson *et al.* 2015).

Thanks to behavioural epigenetics, we also know that social factors might regulate gene expression and functional genomic responses (Cole *et al.* 2007). It has been found in mammals that social conditions can modulate the expression of neural genes such as the glucocorticoid receptor gene (Zhang *et al.* 2006), the nerve growth factor gene, and the key immune system genes (Sloan *et al.* 2007). Roth *et al.* (2009) showed that pups raised by stressed-out mother rats exhibited increased methylation of brain-derived neurotrophic factor (BDNF) gene in the central nervous system, and they observed a transgenerational perpetuation of changes in gene expression and behavior induced by early abuse and neglect. Weaver *et al.* (2004) showed that increased pup licking and grooming and arched-back nursing by mother rats altered the offspring epigenome, and Curley *et al.* (2009) showed that an enrichment of the postnatal environment may exert sustained effects on behavior through modification of oxytocin and vasopressin receptor densities. Among human beings, epigenetics processes are increasingly well documented, and they begin to be considered by social scientists (Thayer & Non 2015), especially because some of them could be transgenerational (Heard & Martienssen 2014; Nestler 2016). In our species, it is well known that social stress and isolation may affect the onset and progression of disease,

while socially supportive interactions contribute to reduced mortality risks (Seeman 1996). Low levels of social support and high depressive symptoms can regulate tumor cell gene expression among women with ovarian cancer (Lutgendorf *et al.* 2009). Oberlander *et al.* (2008) reported epigenetic alterations in cells isolated from umbilical cord blood in 33 infants born to women who suffered symptoms of depression during their pregnancy, suggesting an increased susceptibility to stress among the newborns. Adverse environmental conditions during early-life can cause epigenetic changes in humans that persist throughout life, and have effects on behaviour (Keverne, Plaff & Tabansky 2015). For instance, the strong sensitivity to diseases for individuals who were prenatally exposed to famine during the Dutch Hunger Winter in 1944-1945: according with the fetal origins hypothesis (Barker 1995), sixty years later they had less DNA methylation along the insulin-like growth factor II gene *(*IGF2), compared with same-sex siblings not exposed to the famine (Heijmans *et al.* 2008). Other persistent changes in epigenetic regulation have been observed among people who suffered the Great Chinese Famine (1958-1961) or the 1968-1970 Biafra famine (Ahmed 2010).

Another example of the action of cultural matrices on genes is resistance to some diseases. For instance, due to the diversity of environmental and social conditions, resistance to malaria was promoted, directly or indirectly, in West Africa by the practice of agriculture (yam cultivar) as the environment in which resistance through the sickle cell gene emerged (Livingstone 1958), in Coastal New Guinea by the use of sago palm (Ulijaszek 2007), and in the Mediterranean by fava bean consumption (Katz & Schall 1979). If we consider mental health, it is well known that adverse early-life experiences have a profound effect on the developing brain (Nemeroff 2004), but a lot of data shows that genes and culture interact. Here are just a few examples. In men who were abused as children, the expression in the hippocampus of a gene involved in stress control is affected even decades later (McGowan *et al.* 2009). On one hand, variation in specific genes (monoamine oxidase A (MAOA) and serotonin transporter (5-HTT)) contributes to predict greater or lesser degrees of psychopathology in maltreated individuals (Kim-Cohen & Gold 2009), but on the other hand, social factors can promote resilience. According to the social buffering hypothesis, having a supportive relationship with an adult protects maltreated children from developing depression and reduces behavior problems, even among children who have an at-risk genetic makeup (Kaufman *et al.* 2006). Also, socioeconomic status early in life seems to alter gene expression. According to the research of Miller *et al.* (2009), the white blood cells of men who lived in lower socioeconomic environments before the age of 5 show disparities in the activity of more than 100 genes related to immune system function. As a result, they observed an increase of inflammatory immune responses, and infectious and cardiovascular diseases, all phenomena related to poverty. Strictly speaking, even if epigenetics does not always seem to be the cause – changes in gene expression can be the result of changes in the activity of transcription factors without the help of epigenetic mechanisms (Miller 2010) -, the important lesson for anthropologists and biologists is that social interactions can affect biology.

2.1.2 The Cultural Brain

Among human beings, the power of culture is often explained by the power of the brain, acquired at the price of substantial developmental and energy costs which, from an evolutionary point of view, can be justified by the extent of the behavioral palette or repertoire that brain power ensures to our species (Sol 2009). This standpoint is right but it eludes an essential fact: if our brain is so powerful, it is also because culture can act on it or, more exactly, because the nature of our brain makes it especially suited to being culture-dependent. Thus, the human brain is shaped by both evolution (phylogenesis) and culture (Richerson & Boyd 2005; Schaller *et al.* 2009).

In various ways, our brain differs from that of other primates. If we put aside the still debated discovery of "Hobbit" (*Homo floresiensis*) on Florès Island (Brown *et al.* 2004; Sutikna *et al.* 2016; Weston & Lister 2009), the established fact is that, throughout evolution, brain size in hominins has always increased. At birth, cranial capacities were on average 180 cc among *Australopithecus*, 225 cc among early *Homo*, 270 cc in *Homo erectus*, and approximately 370 cc among anatomically modern humans. The size

of the skull of a newborn human being is about 2.5 times bigger than that of a chimpanzee. The price to pay for this – a long, risky and dangerous labour, in contrast to other primates (Ponce de León 2008) – has as compensation a strong encephalization quotient (EQ). In our species, EQ is about 6.9 times higher than that of an average mammal with the same weight, and it is 2.6 times higher again than that of a chimpanzee. The power of our brain results not only from its size and its volume, but also from the number of neurones (about 86 billion on average, compared with about 28 billion in chimpanzees), the complexity of their interconnectivity (about 10^{14} synapses), neotenic changes present at the gene expression level (Somel *et al.* 2009), its voracious appetite for energy (Pontzer *et al.* 2016), its constant vigilance, and equally from its structure. Encephalization translates into increasing and significant specializations of cortical and sub-cortical areas, notably in the increase in the size of the temporal and frontal cortices, which play an essential role in our aptitude for sociality and in cultural representations.

The idea that the advanced cognitive abilities of the human brain were evolutionary shaped (and are still being shaped) by social factors is central to three related hypotheses - Social Brain Hypothesis (H.), Cultural Brain H., Cultural Intelligence H. (Dunbar 1998, 2003 & 2007; Herrmann *et al.* 2007) -, according to which it is mainly the computational demands of living in large, complex societies that selected for large brains, and not the brain's role in sensory or technical competences such as foraging skills, innovations, and way-finding. In the same way, the Vygotskian Intelligence H., the Shared Intentionality H. and the Machiavellian Intelligence H. argue that both the adoption of cooperative behaviors and the existence of social competition, communication and teaching among early humans led to more conceptually complex forms of thinking (Byrne & Whiten 1988; Call 2009; Tomasello 2014). It has also been argued that the cultural invention of cooking increased caloric content and so freed more energy for the brain (Wrangham *et al.* 1999; Wrangham 2009), what allowed the increase of the number of neurones and consequently (Fonseca-Azevedo *et al.* 2012) of the brain. So, throughout its evolution, the human brain was largely shaped (and is still being shaped) by cultural matrices. Furthermore, beyond evolutionary shaping, it is also similarly shaped after birth and through the entire life span, thanks to its amazing plasticity. The human brain is a never-ending construction. From conception (Mampe *et al.* 2009; Partanen *et al.* 2013) to death, it is encultured (Lende & Downey 2012) i.e. open to cultural sculpting at multiple levels.

2.1.3 The Encultured Brain

2.1.3.1 Altriciality

One *Homo sapiens'* characteristic is the strength and duration of the growth of a large percentage of the brain postnatally. If we consider the variable of strength, the species which is phylogenetically the closest to our own – *Pan troglodytes* – has a coefficient of brain growth of 2.5 between birth and adulthood, contrasted with 3.3 in humans (DeSilva et Lesnik 2006 & 2008). If we consider the variable of duration, the continued growth of the brain is embedded in a general schema which concerns the whole organism: the human infant, for at least 160 000 years, has needed much more time to develop than other animal species. We, as *Homo sapiens*, experience this so-called secondary altriciality (Coqueugniot *et al.* 2004) in addition to the primary altriciality – we are not immediately competent at birth without social support. For the most part, the brain stops neurogenesis soon after birth, except in the subventricular zone - which connects to the olfactory bulbs - from where new neurons integrate into the adjacent striatum (Ernst *et al.* 2014), and in the subgranular zone, part of the dentate gyrus of the hippocampus (Eriksson *et al.* 1998). However, the neonatal brain only represents 25% of its adult size. Immediately after the birth of a baby, the growth will proceed at the same rate as during the foetal stage to reach 50% of the adult size around 1 year and 95% around 10 years. This growth essentially concerns the interconnections of the neurones (synaptogenesis). The growth is progressive and goes through several phases, of which one is rapid and the others are slower. The duration of the rapid phase is 14 days in rats, 30 days in cats, 136 days in monkeys/apes, and 470 days in humans (where it starts 4.5 months before birth). At every minute in the life of a baby, recalls Changeux (2002: 291), "more than two million synapses are occurring!" In total, 50% of these connexions occur after birth (Changeux

2003). After the rapid phase, brain development is long lasting. For example, the stabilization and selective elimination of the initially overproduced synapses (Changeux & Danchin 1976) in the cerebral cortex (synaptic pruning) was long considered complete during early adolescence. Yet Petanjek *et al.* (2011) showed that the period of overproduction and elimination of dendritic spines on pyramidal neurons in the human prefrontal cortex extends to the third decade of life. According to Kolb *et al.* (2012), cerebral maturation is not complete until an individual reaches her or his fourth decade of life. Not even the higher non-human primates experience such secondary altriciality. Indeed, at birth, chimpanzee brain capacity is 40% of adult capacity, but it reaches 80% as early as 1 year compared with, as we know, 50% in humans. This prolonged development of the brain is indisputably a peculiarity of our species. Usually, and often rightly, this peculiarity is considered as an advantage, because it has a long-range anthropological consequence: our brain is a very effective tool for cultural learning. It is predisposed to become a cultural representation of the world (Changeux 2002). However, a risk associated with "the cultural recycling of cortical maps" (Dehaene & Cohen 2007) is rarely noted. This predisposition can produce the best yet it can also produce the worst, depending on the nature of the context.

It can produce the best. For instance, there is a significant effect of early childhood maternal support on hippocampal volume growth across school age and early adolescence (Luby *et al.* 2016). Infants born extremely prematurely who are exposed to audio recordings of maternal sounds (including their mother's voice and heartbeat) have a significantly larger auditory cortex bilaterally compared with control newborns receiving standard care (Webb *et al.* 2015). Only 15 months of musical training before the age of 7 years can strengthen connections (corpus callosum) between the two hemispheres of the brain (Schlaug *et al.* 1995) and induce other structural brain changes in motor, auditory, and visual-spatial regions (Gaser & Schlaug 2003; Hyde *et al.* 2009). Early musical training staves off hearing loss (White-Schwoch *et al.* 2013). Reading books and educational toys influence how the brain grows (Yeatman *et al.* 2012).

However, the predisposition of the brain to become "a cultural representation of the world" can also produce the worst. Numerous studies on fetal vulnerability and adverse early-life experience document how some cultural matrices may cause cognitive damage. They may lead to telomere shortening, associated with age-related illnesses like Alzheimer's disease (Mitchell *et al.* 2014). They can compromise neurobehavioral development (e.g. impacting hippocampal development, affecting the development of the myelin-producing glial cells, or impairing brain connections) and the corresponding cognitive development of children (mental retardation, emotional instability, low executive and memory function, reduced language skills, addiction vulnerability, etc.). Variation in specific genes (monoamine oxidase A and serotonin transporter (5-HTT)) helps to predict greater or lesser degrees of psychopathology in maltreated individuals (Kim-Cohen & Gold 2009). BDNF expression and DNA methylation are altered in several psychiatric disorders that are associated with early-life adversity (Hair *et al.* 2015, Kundakovic *et al.* 2015). Similarly, poverty affects the growth of children's brains (Kimberly *et al.* 2015; Luby *et al.* 2013), a crucial issue in the contemporary context of rising social inequalities.

2.1.3.2 Neuroplasticity

The important lesson is that cultural matrices affect the biology of the brain – culture is "embrained" (Kitayama & Uskul 2011; Mu, Kitayama *et al.* 2015) - for better and for worse. This phenomenon is not limited to the first decades of human life. It is extended by the process of neuroplasticity (the modification of neural networks and synaptic strength) all throughout life. Neuroplasticity can be opportunistic, honed through development and evolution, or context-dependent. Behavioral experience-induced structural plasticity is not specific to human beings (Rampon & Tsien 2000) and, from an ontogenetic point of view, it is well documented that practice makes cortex (Duerden & Laverdure-Dupont 2008). For example, grey and white matter changes are associated with tool-use learning in Macaque monkeys (Quallo *et al.* 2009). However, this behaviorally induced brain plasticity is massive among human beings. All throughout life, many neural correlates of human cognition are

culture-dependent (for a review, see Han & Northoff 2008), and many cultural practices induce brain structural plasticity, notably various learning and memory processes such as procedural learning, skill learning, habit learning and reward-associated learning.

For example, hippocampal plasticity in adults has been related to intensive musical training (Herdener *et al.* 2010). In adults as well, learning to read re(de)fines the cortical networks for vision and language (Dehaene *et al.* 2010), increases white matter in the splenium of the corpus callosum, and grey matter in bilateral angular, dorsal occipital, middle temporal, left supramarginal and superior temporal gyri (Carreiras *et al.* 2009), and, globally, influences the functional hemispheric balance in reading and verbal working memory-related regions and affects large-scale brain connectivity (Petersson *et al.* 2007). Long-term meditators have structural differences in both grey and white matter (Kang *et al.* 2013; Tang *et al.* 2010). Cortical thickness is correlated with duration of video gaming (Kühn *et al.* 2014). Among taxi drivers, the volume of grey matter in the right posterior hippocampus was found to correlate positively with the amount of time spent learning to be, and practicing as, a licensed taxi driver (Maguire *et al.* 2000, McNamara & Shelton 2003; Woollett & Maguire 2011). An increase in grey matter density has also been observed among bilingual people compared with monolingual people (Kovács & Mehler 2009a, 2009b; Mechelli *et al.* 2004), among people learning a new motor skill such as juggling (Draganski *et al.* 2004), among subjects who practiced a mirror reading task for 2 weeks (Ilg 2008), during extensive learning (Draganski *et al.* 2006), grey matter volume is correlated with quantitative measure of participation in social networks (Kanai *et al.* 2012), etc. The adult neurogenesis in the hippocampus and the olfactory bulb is not static or merely restorative, but constitutes an adaptive response to interactions with our environment and/or our internal state (Lledo *et al.* 2006). The perfumers' expertise is associated with a functional reorganization of key olfactory and memory brain regions (Plailly *et al.* 2012). Sensory inputs enhances synaptogenesis of adult-born periglomerular neurons (Livneh *et al.* 2009). This induced brain structural plasticity never stops completely during adulthood, and can still be observed among older people for whom this mechanism is strengthened by cognitive engagement and exercise (Boyke *et al.* 2008; Park & Reuter-Lorenz 2009; Willey *et al.* 2016). This neuroplasticity has correlates in human cognitive abilities.

2.1.4 Enculturated cognition

Heyes (2012) argues that it is not only 'grist' (facts about the world and how to deal with it) but also 'mills' (the cognitive processes that make 'fact inheritance' possible) that are culturally inherited, a process called "cognitive retooling" by Wilson (2010). So, cognition is intrinsically a cultural phenomenon (Hutchins 1995). It is well known that, according to their social origin, people do not have the same chances of mastering their native language, having access to greater knowledge and thus succeeding in academic studies (Bourdieu & Passeron 1964). For instance, there is a huge power of cultural matrices on child development, and on what I coined protomemory (Candau 1998a). Prenatal undernutrition impedes cognitive function (de Rooij *et al.* 2010), as does the rise in childhood obesity (Yau *et al.* 2012), and as does poverty (Hair *et al.* 2015; Mani *et al.* 2013). Just the fact that high socioeconomic status (SES) families use gesture more to communicate with their children when they are 14 months old is a precursor at 54 months to the inequality with children from low–SES families who, on average, arrive at school with less vocabulary (Rowe & Goldin-Meadow 2009). Musical intervention with nine-month-old infants enhances infants' ability to extract temporal structure information and to predict future events in time, a skill affecting both music and speech processing (Zhao & Kuhl 2016). Two years of music training improves the neurophysiological distinction of consonants among at-risk children aged six to nine years (Kraus *et al.* 2014). Family-based training program improves brain function, cognition, and behavior in lower socioeconomic status pre-schoolers (Neville *et al.* 2013). McLaughlin *et al.* 2015 provide causal evidence for the persistent effects of the early caregiving environment (e.g., deprivation associated with institutional rearing in Bucharest) on the stress response system. In fact, there are several ways in which culture can influence perception and cognition across a variety of domains, including self-representation (Zhu *et al.* 2007), attention (Grossmann et al. 2011), memory (Mullen & Yi 1995), theory of mind (reading literary fiction improves it: Heyes & Frith 2014;

Kidd & Castano 2013), or stress responses. From a general point of view, early adversity can damage not only physical growth (Juonala *et al.* 2016), but also neurodevelopment, executive function abilities (cognitive flexibility, working memory, inhibitory control), and social-psychological health (Berens & Nelson 2015; Hostinar *et al.* 2012).

According to the Flynn (1987) effect (large increases in IQ over short periods of time as nations develop), it is very plausible that health, nutrition, literacy, and schooling improve IQ (Barber 2005). A prospective, population-based birth cohort study of neonates launched in 1982 in Pelotas (Brazil) shows that breastfeeding, a culturally differentiated practice since the first hour of life of newborn (Candau *et al.* 2016)[2], is associated with improved performance in intelligence tests 30 years later (Victora *et al.* 2015). Conversely, a change either in general societal pressures on the individual or in the style of teaching in schools favoured a large drop in performance by English 11- / 12-year-olds entering secondary school between 1976 and 2003, namely a large anti-Flynn effect (Shayer & Ginsburg 2009). Contrary to the myth of the solitary genius, even creativity is always collaborative and thus context-dependent, even when we are alone (Sawyer 2008).

From a Whorfian perspective, language may change how we see the world. Language influences biological concepts (Anggoro, Medine & Waxman 2010), color cognition, especially color memory, learning, and discrimination (Davidoff 2001; Davidoff *et al.* 1999; Deutscher 2010; Kay & Regier 2003; Özgen & Davies 2002; Regier, Kay & Khetarpal 2007; Roberson *et al.* 2005; Uchikawa & Shinoda 1996), economic behaviour (Chen 2012), emotional perceptions (Gendron *et al.* 2012), numerical cognition (Gordon 2004; Pica *et al.* 2004), olfactory cognition (Candau 2003; Majid *et al.* 2014; Sorokowska *et al.* 2013), perception of motion events (Athanasopoulos *et al.* 2015), perspective-taking (Fan *et al.* 2015), spatial cognition (Majid *et al.* 2004) and spatial concepts (Choi & Bowerman 1991), and visual awareness (Lupyan & Ward 2013). In my own research, ethnographic and experimental data show that repeated olfactory experiences give to some professionals a real sensorial expertise when they have to identify, discriminate and categorize odors (Baccino *et al.* 2010; Candau 2000 & 2004; Candau 2015, 2016).

Religious practice can induce biases in the control of visual attention (Colzato *et al.* 2010). Even some reputedly hard-wired or "encapsulated" cognitive processes (impenetrable or unaffected by other cognitive domains and by the cultural environment) and, therefore, thought to be invariant across all humans, are not so. For example, Segall (1966) demonstrated the cross-cultural variation in the Müller-Lyer visual illusion. Similarly, the Ebbinghaus illusion has been shown to be stronger in Japanese than Western observers, and stronger in Western than Himba (Namibia) observers (Caparos *et al.* 2012). Face processing, observed in newborn infants, is beyond doubt an innate capacity (Goren *et al.* 1975; Johnson *et al.* 1991). However, this processing differs across cultures (Blais *et al.* 2008), providing evidence of cultural tuning of an automatic neural response. In these last cases, culture influences cognitive abilities that biologists previously believed to be hard-wired in our species.

As for induced brain structural plasticity, the experience-dependent plasticity of cognitive abilities can still be observed among aging people. Emerging research into emotional, social, and motivational domains provides some evidence for the preservation of plasticity with age (Gutchess 2014). For instance, current research on language and aging shows that older adults' brains remain responsive and capable of flexible network interactions (Shafto & Tyler 2014). Exercise, eating habits, literacy skills, socially engaged life, and even some video games protect against memory decline and consolidate gains (Anguera *et al.* 2013; Caracciolo *et al.* 2014; Lindenberger 2014; Manly *et al.* 2004).

2.2 Current responses of science to the effects of culture on cognition

Several disciplines focus on this topic. None, however, put at the heart of their research questions on the issue of the DVoCM, as I do in this article. So-called "Comparative cognition" (Comparative Cognition Society; numerous Comparative Cognition Laboratories: Indiana University, University of

[2] https://colostrum.hypotheses.org/

Cambridge, University of Kentucky, University of Newcastle (Australia), University of Wisconsin, University of Neuchâtel, Yale University, etc.), various publications on comparative cognition: journal *Comparative Cognition & Behaviour Reviews,* recent books such as Olmstead & Kuhlmei 2015) is outside the DVoCM scope, since it is primarily concerned with comparing the cognitive abilities across species (human species included) or within a non-human species. In contrast, cultural psychological studies (*e.g.* represented in the journals *Culture & Psychology*, *Journal of Cognition and Culture*), and the burgeoning field of cultural neuroscience (for a review, see Han *et al.* 2013) have paved the way, arguing that an intrinsic feature of the brain is that it is culture-dependent. Cross-cultural psychology*,* briefly defined by Berry *et al.* (2002, 1st edition 1992) as the study of the relationships between cultural context and "psychological functioning," has also been a pioneer in the domain. Yet even when Muggleton and Banissy (2014) note that "there is increasing interest in specific neurocognitive differences that may arise as a consequence of different cultural backgrounds", it is never focused on the DVoCM.

The recent (2014-2017) *Enculturated Cognition Project* (P.I. Richard Menary, Macquarie U., Australia) plans to explore how culture transforms the brain and extends our cognitive capabilities. However, Menary's scope is the entire human species and its general ability to culture in an evolutionary perspective. With a similar perspective, the *Laland Lab* (U. of St Andrews, U.K.) emphasizes how, throughout evolution, cultural processes amplify our capacity for niche construction and our ability to modify selection pressures accordingly. Although I am enthusiastic about a Darwinian approach to culture, these evolutionary perspectives are different in nature from the topic of this article, which is centered on the variability of the DVoCM.

Many other research lines are centered on culture-cognition interactions. I should mention *The Cultural Brain-initiative* (*Den kulturella hjärnan*, Sweden) which gathers data in the cross scientific field of research where culture, brain, health and education meet each other; the field of neuroanthropology (Lende & Downey 2012), which explores the interaction of brain and culture and its implication for the understanding of mind, behavior, and self; or the focus of the *International Cognition & Culture Institute* (*LSE* and *Institut Jean Nicod*) in the emerging cross-disciplinary field of cognition and culture studies. Even initiatives towards "Cognitive Reports" are emerging. Since 2012, a private initiative of the Economist Intelligence Unit, *The Global Index of Cognitive Skills and Educational Attainment*, has provided a snapshot of the relative performance of 39 countries based on their education outputs, but it neglects the DVoCM as a whole. This remark also applies to the *Survey of Health, Aging and Retirement in Europe* (SHARE), where participants were tested on cognitive tasks assessing episodic memory and category fluency. Subtitled *Mind, Society, and Behavior*, the key message of the *World Development Report 2015* is that poverty is a "cognitive tax", a real mental toll. For example, sugar cane farmers in India were asked to participate in a series of cognitive tests before and after receiving their harvest income. Their performance was the equivalent of 10 IQ points higher after the harvest, when resources were less scarce (WDR 2015). However, the WDR 2015, as with the other initiatives above, is not systematically focused on the DVoCM.

These different initiatives are dispersed, they do not have a unifying theoretical framework around a well-defined research object, and their heterogeneous methodologies often make it difficult to compare the available data. It results that we have a lot of scattered data, without a unifying theory. In this domain, literature teaches us that culture influences our brains and also gives us information – that must be rigorously evaluated - about what culture does to our cognitive abilities. However, it does not venture any global perspective about the correlations, and even less about the causal relationships that could be established between the cultural matrices and our cognitive abilities. Although the question of the DVoCM is often implicit in this various researches, it is never asked explicitly. This research path remains untrodden, which justifies the goal of DVoCM studies.

3. THE GOAL OF DEVELOPMENTAL VALENCE OF CULTURAL MATRICES STUDIES

The aim of these studies is to establish whether we can identify and then evaluate (T+ or T-, with all

of the levels in between) the DVoCM, just like we can identify and then evaluate the sanitary valence of a socio-physical configuration when we examine the physical health of its members. For example, if we evaluate the sanitary valence in the Caribbean, we can confirm that it is better in Cuba than in Haiti in terms of infant mortality: the rate was 4‰ and 42‰ respectively in 2015. Strangely, since it involves evaluating the cognitive (broadly speaking) development of individuals, scientists do not risk this kind of judgment on contemporary cultural matrices. At best, when they do so at the level of big or small groups (a society, a family, the working conditions in a company, a sect), the question is asked in terms of mental health, i.e. compared with the risk as to whether or not these groups induce certain pathologies (Demeinex 2014; Gold & Gold 2015; Grandjean 2013). Yet the question of cognitive development is never asked head-on and systematically in terms of the DVoCM. In this article I propose, on the contrary, that this DVoCM may have T+ or T- effects on the cognitive development of individuals.

For an anthropologist, this hypothesis is not easy to formulate. It constitutes a break from the largely dominant relativist tradition of the discipline, which involves refusing to make qualitative judgments on cultural matrices. It is the cornerstone of the discipline, even if some, such as Nettle (2009), pertinently ask if cultural traditions benefit or oppress individuals, and if others discuss the topic of "harmful cultural practices" (Lawson *et al.* 2016; Rieger & Wagner 2016). Apart from a few rare exceptions (Turnbull 1972), most anthropologists adopt the principle of axiological neutrality, with the result that the possible negative effects of culture have rarely been considered. The dominant opinion among anthropologists is all the more robust as, whatever the cultural matrix considered, it generally corresponds to that of the people living in this context. Generally speaking, these people consider that their culture is "good" on the whole (and often consider it as superior to others). Besides the in-group and herding biases it probably lies in the fact that, for lay people, culture is an incremental process of acquisition, which is continually improving. Consequently, for lay people (their) culture is generally good, and for anthropologists, culture is not necessarily good, but the blinkered thinking is that culture cannot be bad.

Contrasting with this view, I argue that the scientific assessment of the DVoCM is a relevant goal, in the same way as we assess the "sanitary valence." I address this issue directly. To restate the simplistic example from the start of this text, I make the hypothesis that the developmental valence of a cultural matrix where the main television media dedicates a large part of its activity to selling "available human brain time" to a company advertising a famous fizzy drink is not necessary favorable to the cognitive development of individuals (possibly, an example of cultural adversity). Breaking with the tradition of my discipline in this way is high-risk from a scientific point of view, and also from an ethical one: the risk is of creating, involuntarily or voluntarily (ideological manipulation), hierarchies among populations belonging to cultural matrices where the developmental valence is irregular, which would be contrary to the agreement of all anthropologists, myself included, and, I presume, of the vast majority of scientists, about the psychic unity of humankind, within what is considered as normal inter-individual variability (Tavor *et al.* 2016). The meaning that I give to the notion of "cultural matrix" should prevent this risk.

3.1 Cultural matrices.

What is culture? As we know, at least since Kroeber & Kluckhohn's seminal book (1952), the notion of culture is a veritable cornucopia for often incompatible definitions. So, tentatively, I substitute the notion of cultural matrix to that of culture. Like I said previously, a cultural matrix is a generative socio-physical configuration of a temporary stable deep sharing (i.e. behavior and representations) between individuals caught in the matrix. This form of sharing - in terms of everyday practices, ways of sensing, feeling, thinking, believing, etc. -, is not fixed although relatively stable because it results from a socially transmitted heritage specific to a particular socio-physical configuration. Each form of sharing is a cultural matrix, whatever the number of individuals who are sharing. This definition has the benefit of being operational. Indeed, when defined in this way a cultural matrix can be observed at very different levels: a family, a community, a company, a school, a village, a district, a region, a country, etc. So what

are the relevant observation levels for evaluating the DVoCM? Are they all relevant? Should some of them be prioritized? Is the most relevant approach to combine several observation levels, from the most local level to the most global? This article can only be limited to the question. However, I shall already specify what I do not want to focus on. In cultural neuroscience, it is common to make comparisons between vast cultural matrices. Classically, scientists compare "Western culture" *vs* "East Asian culture" to try and find out, for example, if people have independent thinking or interdependent thinking of the self, or if they use analytical thinking or holistic cognition (Nisbett *et al.* 2001). Without neglecting this work on putative culturally specific cognitive styles on a scale of immense cultural areas, the perspective does not seem to me to be the most relevant one. A cultural matrix identified on this scale can hide large internal differences (a good example is Talhelm *et al.* (2014), who explains major psychological differences within China by rice *vs* wheat agriculture, or Uskul *et al.* 2008, who describes different holistic tendencies in Turkey in three types - farming, fishing, and herding - of communities that belong to the same national, geographic, ethnic, and linguistic regions). Consequently, the risk of overgeneralization and excessive essentialization is very high. Within what has been identified as a cultural matrix using a certain lens, a closer lens can identify a mosaic of matrices, some of which can be T+ and others T-. Furthermore, even within a cultural matrix observed at the smallest scale, the relationships with the cognitive abilities may be neither homogeneous nor constant: some factors can be T+ and others T-; across an individual's life, these factors can change; in contemporary societies, people are increasingly rarely monocultural, etc. My definition of the cultural matrix is far from perfect but it enables us to start the research. The preferred approach here is to start working on restricted groups and then to expand the scope if necessary.

3.2 What is "good," what is "bad"? What is a starting cognitive potential?

My distinction between T+ and T- no implies a normative conception of the cognitive (broadly speaking) development induced by the Theuth effect. To argue that T+ and T- exist induces two questions. "More" and "less" compared to what initial conditions of the brain? "More" and "less" compared to what normal development of the brain? In answering the first question, I want to emphasize three important points. Firstly, in the humanist perspective of social sciences, any society is a priori equal in dignity. Secondly, because the psychic unit of mankind (Youn *et al.* 2016), any society is as rich in Pasteur and Palissy that another, as wrote Lévi-Strauss (1973:407), at least *potentially* (my addition). Thirdly, in the framework of this psychic unit, the controversial issue of cognitive inequality at birth is beyond the scope of DVoCM studies. One of two things: these inequalities either exist or they do not. In both cases, the issue remains unchanged. If, as is most likely (Deary *et al.* 2012; Joshi *et al.* 2015; Okbay *et al.* 2016), inequalities exist, what is at stake is always to determine the DVoCM: does it induce gain or loss compared to the starting cognitive potential? If these inequalities do not exist, the challenge is the same. Even if human beings were like cognitive clones at birth, it would still be relevant to assess the DVoCM. In one case as in the other, the issue is whether the Theuth effect is positive or negative. However, the fact that our own intra-species variation in terms of individual cognitive abilities is beyond the scope of DVoCM studies must not hide a serious methodological difficulty. Since the objective is to find out if the DVoCM induces gain or loss compared to a "starting cognitive potential", it is essential to measure this potential as precisely as possible. Psychologists master a large number of methods, tests and techniques that make it possible to measure the cognitive resources of individuals. A possible research program will take stock of these, evaluate their relevance and also seek to develop new tools for improving the evaluation of starting cognitive potential (for example, tools integrating *etic* and *emic* data, objective and subjective parameters, quantitative but also qualitative criteria, etc.).

Let us consider the second question. Leaving aside pathological cases and mental disorders, do we have to presume that a "standard" or "normal" state of cognitive development exists? A relativist view would argue that a normally developed brain allows an individual to be perfectly adapted to her or his environment. So, the Inuit developed specific cognitive abilities in spatial cognition – until the arrival of GPS (Aporta & Higgs 2005; Milner 2016) – which allowed them to orient themselves based on the ice-floe, something which people socialized in other environments would not be able to do. We can say

the same thing for the waiters in *Café de la Paix* in Paris who are capable of memorizing long lists of orders. Of course, Inuit and waiters in the *Café de la Paix* have to use different cognitive aptitudes because they have to process different stimuli and information, but both seem well-adapted to their environment. So, from an anthropological point of view, the notion of a "standard" or "normal" cognitive development does not seem very relevant because its norms are relative in this domain.

However, this relativistic definition avoids two problems. Firstly, we can imagine a society perfectly adapted to its environment when we consider a certain temporal scale, but unadapted when we consider a longer temporal perspective. For instance, imagine talented human beings in an industrial country who have developed the best possible cognitive abilities in order to practice their activities. They can thus ensure an optimal lifestyle for their group (high GNP, reduction of conflict, demographic progress), but in the long term create such a strong anthropic pressure that their ecosystem would be condemned. Secondly, environments are always changing, particularly in a context of globalization and increasing human migrations. Therefore, we cannot affirm that a cultural matrix which shapes a brain that is very well adapted to a certain environment will always be able to allow that same brain to express all the potential of plasticity that would be necessary in the case of big changes in the environment (e.g. *Collapse* of civilizations, Diamond 2011). I will venture a definition of optimal cognitive development: it has this quality when it enables each individual to provide the best possible behavioral responses, whatever the diversity of the situations she/he copes with, particularly in the presence of those with which she/he never coped. The optimal cognitive development is one that has this protean capacity.

Here, we reach the nub of my argument. I argue that some cultural matrices, or that some components of these cultural matrices, can either favor this protean capacity (T+) or, on the contrary, curb it (T-) with, as a result, adaptive or counter-adaptive trends respectively. The DVoCM will be positive when the expectations, requirements and resources of this context enable the optimal exploitation by each individual of her or his starting cognitive potential, equal in extent and intensity: T+ is the flourishing of the cognitive abilities (cultural felicity). The DVoCM will be negative when on account of the expectations, requirements and resources of the cultural matrix, the starting cognitive potential of each individual is "cut down", "amputated" or, to use a metaphor, constrained as a *bonsai,* or when this potential is "funneled", that is to say one cognitive resource is overexploited to the detriment of others, for instance, rational thinking to the detriment of the emotional or sensory thinking: T- is the withering of the cognitive abilities (cultural adversity).

3.3 Things to do

This article presents a new field of research, which is designed to be hypothesis-generating in DVoCM studies, and to make in-roads in methodology. To achieve these general objectives, what should we do?

3.3.1. A critical literature and theories review.

The first goal is to identify and collect the most relevant literature about the notion of DVoCM in cognitive anthropology, developmental and cognitive psychology, cognitive neurosciences, cultural and social anthropology, cultural neurosciences, cultural psychology, ethology, social neurosciences, social psychology; to identify the different theoretical frameworks; to evaluate the limits and significance (analysis); and to make a synthesis of the reliable data published on the topic. This task will be long and complex because the literature on this question is not always consistent: small samples of convenience; frequent confusion between correlation and causation; WEIRD bias (*see the following section*); false-positive rates; over-generalizations of results; absence of replication; excessive simplicity of some neurobiological experiments, particularly the conceptualization and theoretical foundation of social behavior; confused metaphors; hazardous transposition to humans of experiments focused on rodents or non-human primates.

The choice of topics to be discussed in the literature review can be made on the basis of two types of criteria: either a well identified cognitive skill or a response to a social or theoretical question. In terms of the first criterion we could, for example, choose to discuss data relating to the faculty of memory or numerosity in literature and in various cultural matrices. However, when making these choices we must be careful not to create and fix a hierarchy of cognitive abilities. In fact, the list of these, which is both long and imprecise, cannot be exhausted in the framework of an item by item approach. The risk thus lies in reaching the conclusion that the retained cognitive abilities are the most important ones. If we consider the following abilities that, in literature, show a variability depending on the cultural matrix, how do we decide which should be favored to evaluate the developmental valence of such a context: *aesthetic cognition* (creativity, preferences, sensitivity), *attentional processes* (attention, mind wandering, shifting), *discourse* (argumentation, ability to synthesize, mastering language), *emotion* (empathy, expression, feelings, moods, preferences, representations), *general cognition* (categorization, causal inferences, cognitive reserve, concept formation, counting, curiosity, decision-making, doubt, epistemic norms, epistemic needs, imagination, innovation, intelligence, intuition, logic, memory, metacognition, reasoning (abductive, analogical, deductive, inductive, probabilistic, diagrammatic)), *moral abilities* (fairness, feeling of (in)justice, humour), *perception* (sensory processes, sensitivity, sensory dominance, sensory preferences), *self-regulation* (ability to cope with stress, autotelism (flow), doubt, risk-avoidance, resilience), *social abilities* (communication, cooperative behaviors, imitation, shared intentionality, social cognition, social learning, mind reading, tolerance), *spatial cognition* (navigation, way-finding), *technical abilities* (tinkering, tool use), *temporal cognition* (timing perception, planning for the future) etc. ? The goal is to reach a scientifically consensual definition of the cognitive abilities to be studied and determine if it is necessary to prioritize some of them in the perspective of evaluating the developmental valence of a given cultural matrix.

A second criterion for choosing the topics to be discussed is to respond to a social or theoretical question that covers various cognitive abilities. For instance, a current question is what are the cognitive effects of new technologies? Are they changing the way we think (Brockman 2011)? Are they producing wonders or wreaking havoc? For some researchers, new technologies are good; for others, they are bad. On one hand, Shermer (2015) argues that the growth of global information and communications networks has led to increasingly educated people, whose access to information undermines pseudoscience, by allowing people to judge for themselves. According to Storm & Stone (2014), saving information on a computer helps to free up cognitive resources that can be used to remember new information. Fisher (2009) argues that swarm intelligence can emerge from the web of interactions between individuals. On the other hand, Ophir *et al.* (2009) have shown that, compared to light media multitaskers, heavy media multitaskers are more susceptible to interference from irrelevant environmental stimuli and from irrelevant representations in memory. Consequently, cognitive performance of chronic multitaskers declines on a test of task-switching ability. According to Carr (2010), we process the immense stream of information provided by Internet in an increasingly shallow manner, with negative effects on attention and memory (Spitzer 2012). Bakshy *et al* (2015) ask if Facebook works as a "bubble filter" and limits exposure to perspectives that cut across ideological lines. Dunbar (2012) argues that social networking sites maintain relatively weak quality relationships and social cognition without face-to-face interaction. There is a broad agreement that a seemingly new psychiatric phenomenon termed *hikikomori* (acute social withdrawal of young Japanese) is a product of the affluence, technology, and convenience of modern Japanese life (Watts 2002). According to Fisher *et al.* (2015), searching for information online leads to an increase in self-assessed knowledge as people mistakenly think they have more knowledge "in the head," even seeing their own brains as more active as depicted by functional MRI images (a kind of overclaiming: Atir *et al.* 2015).

Another example of a social question to be discussed is knowing about the cultural matrices of successful brain aging. By 2050 demographers predict that there will be as many old people in the world as young people, with 2 billion people aged 60 or over and another 2 billion under age 15. The number of people around the world aged 80 and above should show an increase from 69 million in 2010 to 379 million by 2050. In Europe, there are more people over 60 than under 15, and the number of people

aged 80 and above is expected to almost triple in size, from 23.7 million in 2010 to 62.4 million in 2060. The question is whether the extra years gained year on year in life expectancy will be mentally healthy years. What can we do in order to limit age-related cognitive decline – correlatively, to increase cognitive reserve - and elderly dependency? If we admit that "rust never sleeps," how can we avoid the rusting of our cognitive aptitudes? Can we identify cultural cognitive lubricants? From this point of view, what teaching can we draw from research into cognitive science and neuroscience, but also from the diversity of cultural representations and practices relating to human cognitive aging?

A third and last example of a social question is to know whether closed societies or open societies – to use a Bergsonian and then Popperian distinction – offer the best DVoCM? The largest groups in terms of number and the most open (Muthukrishna *et al.* 2014) have more opportunities to innovate. Conversely, the forced or chosen closure of societies seems to be an obstacle to adaptative cultural evolution (Diamond 1978; Henrich 2004), to taking cognitive risks, and to coping whith doubt. According to the 2003 report on development in Arabic countries (UNDP & RBAS 2003), on average only 4.4 translated books per million people were published in the first five years of the 1980s (less than one book per million people per year), while the corresponding rate in Hungary was 519 books per one million people and in Spain 920 books. If we admit that translation of books is one of the important channels for being exposed to new knowledge, does this lack of opening not risk altering the DVoCM?

These are only a few examples of the diversity of the questions raised by DVoCM studies. We can consider many others. Is it possible to articulate the Theuth effect with the issue of the critical periods (Greenhill *et al.* 2015; Wiesel & Hubel 1965) in child development? How do we currently measure cognition (inventory and assessment of psychological tests)? Is the Theuth effect linear or non-linear throughout development over the life-span? In cultural matrices, does the high developmental valence for some cognitive abilities limit the developmental valence for other cognitive abilities as, for example, a reduced response to faces could translate into poorer face-processing skills among expert mathematicians (Amalric & Dehaene 2016; Ansari 2016)? Can we identify prototypical cognitive trajectories, prototypical cognitive niches or prototypical cognitive arenas of T+ or T-? Can some very specific cultural matrices boost brain power and be super-enhancers of cognitive abilities (Sheridan *et al.* 2016)? What about "collective" or "swarm" intelligence (Kurvers *et al.* 2015; Muthukrishna & Henrich 2016)? What are the effects of information overload (Candau 1998b), or of the "Cambrian explosion » coming for robotics (Pratt 2015)? Can the knowledge of the DVoCM help psychiatrists to better detect the pathogenesis of human-specific mental disorders? Does the Theuth effect vary by gender? Is it always possible to distinguish between natural environmental causes and social causes or cultural causes of the cognitive development (Mathew & Perreault 2015)? What are the cognitive effects of civilization (in the Eliasian sense) of social interactions or of their brutalization? What are the effects of the density and quality of social relations? Of the strength of social norms (Gelfand *et al.* 2011)? Of a totalitarian cultural matrix (Voigtländer & Voth 2015). When, in a given cultural matrix, political or cultural choices are made in terms of cognitive development, is there a ratchet effect, i.e. the probability increases that if the first choices are good the following choices will be even better and that they will be worse if the first choices are bad? What are the consequences for our cognitive aptitudes (for instance, the brain sensitivity to social stress) of the urban lifestyle (Alcock *et al.* 2014; Lederbogen *et al.* 2011), now shared by over half of the world population? When and why the group self becomes more important than the individual self (Ellemers 2012; Jacquet 2016)? What cognitive mechanisms are not shaped by the cultural matrix? etc.

3.3.2. Integration of non-WEIRD data.

A characteristic of brain and behavior studies is the under-representation of human cultural diversity. According to a survey (Arnett 2008) of the top psychology journals, 96% of the participants in

psychological studies were from Western industrialized countries — which house just 12% of the world's population. People from **W**estern, **E**ducated, **I**ndustrialized, **R**ich and **D**emocratic (WEIRD) societies - and particularly American undergraduates – are the vast majority of subjects in psychological studies, as they are probably some of the most psychologically unusual people on Earth (Henrich, Heine & Norenzayan 2010). In order to avoid this bias, and thus get a robust definition of the DVoCM and of the Theuth effect, we have to integrate data gathered from ethnographic surveys in various cultural matrices.

Indeed, in a non-WEIRD approach, it is important to reconsider the ways in which cognitive abilities are conceptualized in different cultural matrices, because we only have a very rough idea of the criteria that could enable us to measure the DVoCM. For instance, Berry *et al.* (2002) have shown that the words used by the Cree Indians to define intelligence are rendered in English by *wise*, *respects*, *respectful*, *listens*, *pays attention*, *thinks hard*, *thinks carefully*. These words constitute the core of what the Cree Indians understand by "thinking well." Integrating this type of ethnographic data will make it possible to demonstrate new viewpoints about cognitive abilities and reach a definition of the notion of developmental valence that is more representative of cultural diversity. Consequently, in different cultural settings, we need to investigate the representations of these cognitive abilities, and of the cognitive wellbeing (tentatively defined as the feeling among people of a cognitive development according to needs), with the goal of gathering indicators of these representations at different stages of life. The objective is to give many contrasting examples of relevant *emic* data for the topic. For instance, in an Andean community, how is being smart conceptualized? For students in a Moroccan Koranic school, what is a "well-tuned brain" (Whybrow 2015)? In a French charitable organization, which cognitive aptitudes do people consider as worthy of value?

3.3.3. A World DVoCM Report?

Besides GNP data, we have observatories for health *(World Health Report)* and for happiness (*World Happiness Report*). The *Human Development Report* has an Education index for 187 countries, and The *Inclusive Wealth Report 2014* focuses on education in nearly 140 countries (the selection is expected to cover around 96% of the world's population). Some researchers are trying to assess the "knowledge capital of nations" (Hanushek & Woessmann 2015). We have access to a *Global Youth Wellbeing index* and there is now a *Social Progress Index*, which measures the social progress of each country (133 in 2015). The OECD, for its part, established a historical indicator of "global well-being" from 1820 to the present day, which compares salaries, life expectancy, education level, health, size, quality of the environment, personal safety, inequalities between men and women and political institutions. The notion of *Gross National Happiness* was introduced in the 1970s in Bhutan. I already mentioned the *World Development Report 2015*, subtitled *Mind, Society, and Behavior*. However, we have nothing that could be called a *World DVoCM Report*, which would evaluate the developmental valence of the various cultural matrices in the world. Does it make sense to create an observatory for the DVoCM? This issue may be part of the agenda of the DVoCM studies.

4. CONCLUDING REMARKS: WHY DO I THINK THAT DVOCM STUDIES ARE RELEVANT, TIMELY AND NECESSARY?

Nowadays, our species can act upon itself with a power that was still unimaginable a few decades ago. We perform increasing work on our genes (genetic screening, genome editing, embryo engineering). We have a quite precise idea about the correlations or causalities between the socioeconomic context and physical health in the world. We even have robust hypotheses about the variables in mental health. On the other hand, almost everything still needs to be done in relation to the correlations or causalities between cultural matrices and the development of cognitive skills, without scientists and social protagonists really knowing what is going on. We have a weak understanding of how a cultural matrix contributes to the flourishing (cultural felicity) or withering (cultural adversity) of our cognitive abilities. The aim of DVoCM studies is to better understand what is going on, by making major and genuine

breakthroughs in our capacity to evaluate the Theuth effect.

Science must address this issue. Neglecting Theuth effect is damaging to cultural and social anthropology because DVoCM is an innovative perspective on cultural diversity. Moreover and most importantly, neglecting the Theuth effect has a widespread detrimental effect on contemporary societies. In places where the DVoCM is negative, our species cannot act to improve it. In places where it is deteriorating, our species do not know how to intervene to curtail it. Where it is positive, our species are neither able to monitor how it is maintained nor use it as inspiration for a model to try and apply it elsewhere. Furthermore, we have a tendency to reduce systematically to a strictly individual problem (dispositional orientations) questions that, to varying degrees, are also collective questions because they are linked to the DVoCM. If some people lack attention, empathy, logic, motor and sensory skills, or other social-cognitive behaviors, the causes can be individual, but they can also be environmental (DVoCM). This reductionism prevents us from providing the best possible responses. It prevents us from making the political and cultural choices that could enhance the capacity of our cognitive abilities to flourish. By contrast, the detailed study of the DVoCM should be productive. Countless historical and anthropological data leads us to believe that when, in a given society, the trend enhancing the development of the cognitive capacities is powerful, this society will run less risk of collapse than a society where we observe an inverse trend. In the global context of increased cultural exchanges, identifying and evaluating that which, in DVoCM, illuminates or obscure our brains and our minds is scientifically relevant. Considering both the huge power of human culture and the immense plasticity of our brain, a process that I coined $HS^2 = N^2$ (*Homo sapiens sapiens* = Nature*Nurture, Candau 2009), we certainly will verify that our genetic heritage is not our fate.

Glossary

Anthropic pressure: ecosystem changes due to human activity.
Anthropocene: a proposed geological epoch, succeeding the Holocene, that begins when human activities started to have a significant global impact on Earth' ecosytems.
Autotelism: theory or belief that an activity is an end in itself or its own justification.
Axiological neutrality: in social sciences, describe and analyze social facts without making value judgments.
Behavioural epigenetics: a field of study examining how the expression of genes is influenced by experiences and the environment to produce individual differences in behaviour and cognition.
Critical period: period of development of an individual in which the nervous system is more responsive to environmental stimuli. If the organism does not receive the appropriate stimulus during this "critical period" to learn a given skill or to acquire a given trait, it may be difficult, or even impossible, to develop some functions later in life.
Cultural adversity: when the developmental valence of a cultural matrix induces a loss compared to the cognitive potential of individuals at birth.
Cultural and social neurosciences: a field of study examining how mental, neural and genetic events vary as a function of social and cultural characteristics.
Cultural felicity: when the developmental valence of a cultural matrix induces an added value compared to the cognitive potential of individuals at birth.
Cultural matrix: a generative socio-physical configuration of a temporary stable deep sharing (i.e. practices and representations) between individuals caught in the matrix.
Developmental Valence studies: a proposed new field of study (in this article) examining the effect of cultural matrices on the development of human cognitive abilities, for better or worse.
Emic (*vs* etic): in anthropology, a viewpoint is described as *emic* when expressed by the social group; it is described as *etic* when expressed by the anthropologist. Coined in 1954 by the linguist Kenneth Pike, the terms *emic* and *etic* are derived from the linguistic terms phonemic and phonetic respectively.
Encephalization quotient (EQ): a measure of relative brain size defined as the ratio between actual brain mass and predicted brain mass for an animal of a given size.
Epigenome: the chemical compounds that have been added to the entirety of one's DNA (genome) as a way to regulate the expression of all the genes within the genome. The epigenome can be dynamically altered by environmental conditions (see "Behavioural epigenetics").
Gene-culture co-evolution: a field of study examining how genes and cultural traits interact over long time periods. Gene–culture coevolution is a special case of "niche construction" (see this term below).

Information overload: when too much information prevents access to knowledge or decision-making.
Matrilocal and patrilocal groups: a group is matrilocal when a married couple resides with or near the wife's parents; it is patrilocal when a married couple resides with or near the husband's parents.
Methylation: the addition of a single carbon and three hydrogen atoms (called a methyl group) to another molecule. DNA methylation is an epigenetic process (see "Epigenome" and "Behavioural epigenetics") by which methyl groups are added to Deoxyribose Nucleic Acid (DNA).
Microbiome: the collection of all the microorganisms (eukaryotes, archaea, bacteria and viruses) living in association with the human body. These microorganisms make up about 1 to 3 percent of human body mass.
Neuroanthropology: a new discipline, considering both new findings in the brain sciences and anthropological data, and examining the relationship between culture and the brain.
Neurogenesis: the growth and development of neurons, the process by which neurons are generated.
Neuroplasticity: the brain's ability to reorganize itself by forming new neural connections throughout life.
Niche construction: creation by a species of an important aspect of its environment, often but not always in a manner that increases its chances of survival, and transmission of this environment across generations (see "Gene–culture coevolution").
Numerosity: Intuition of numerical quantity in the human brain (a number sense).
Protoculture: rudimentary cultures, without complex cultural technology, observed among non-human primates and other animal species.
Protomemory: the whole systems of knowledge that automatically wake up at a given time: knowledge and behaviours acquired during early socialization, procedural memory, embodied knowledge, etc.
Resilience: how some people adapt well over time to life-changing situations, adversity and stressful conditions.
Secondary altriciality: the fact that a large portion of the brain's wiring develops over a long period of time while growing individuals interact with physical and cultural environment. This altriciality has social consequences: modern human children require many years of parental support. Secondary altriciality also influences the development of cognitive abilities (Coqueugniot *et al.* 2004).
Social genomics: the field of research that examines why and how social-environmental conditions (urbanity, socioeconomic status, social isolation, etc.) influence human gene expression (see "Behavioural epigenetics").
Sociotransmitters: all the human productions and behaviours that help to establish a social or a cultural cognitive causal chain between two minds. Metaphorically, sociotransmitters between individuals perform the same function as neurotransmitters perform between neurons: they promote connections.
Swarm intelligence: the emergence of an "intelligent" global behavior among a population of individuals interacting locally with one another and with their environment.
Synaptogenesis: formation of synapses (morphologically distinct subcellular junctional structures) between neurons in the nervous system.
Theory of Mind (or mind reading): the cognitive capacity to attribute mental states to others, and to understand them as intentional agents.
Whorfian perspective: according to the American linguist Benjamin Lee Whorf, the structure of a language determines what the individual perceives in this world and how she/he thinks about it.

Annotated Bibliography

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Eriksson P. S., Perfilieva E., Björk E. T. *et al.* 1998. Neurogenesis in the adult human hippocampus. *Nature Medicine* 4(1): 1313-1317. [This article demonstrates the genesis of new cells, including neurons, in the adult human brain.]

Ellemers Naomi. 2012. The Group Self. *Science* 336: 848-852. [This article shows that although people often tend to consider themselves and others as unique individuals, there are many situations in which they think, feel, and act primarily as group members, for the best, or the worst.]

Ernst A., Alkass K., Bernard S. *et al.* 2014. Neurogenesis in the Striatum of the Adult Human Brain. *Cell* 156(5): 1072-1083. [This article demonstrates a unique pattern of neurogenesis in the adult human brain: new neurons integration in the striatum.]

Fan S. P., Liberman Z., Keysar B., Kinzler K. D. 2015. The Exposure Advantage: Early Exposure to a Multilingual Environment Promotes Effective Communication. *Psychological Science* doi: 10.1177/0956797615574699. [This article shows that multilingual exposure may facilitate the development of perspective-taking tools that are critical for effective communication.]

Fehér O., Wang H., Saar S., Mitra P.P., Tchernichovski O. 2009. De novo establishment of wild-type song culture in the zebra finch. *Nature* 459: 564-568. [This article shows that species-typical song culture can appear de novo.]

Feldman M. W., Laland K. N. 1996. Gene-culture coevolutionary theory. *Trends in Ecology & Evolution* 11(11): 453-457. [This article presents a branch of theoretical population genetics that models the transmission of genes and cultural traits from one generation to the next, exploring how they interact.]

Feldman M., Cavalli-Sforza L. 1989. On the theory of evolution under genetic and cultural transmission with application to the lactose absorption problem in *Mathematical Evolutionary Theory*. Edited by Feldman M. W., pp. 145–173. Princeton, NJ, Princeton University Press. [The gene-culture theory applied to the lactose tolerance problem.]

Fisher L. 2009. *The Perfect Swarm: The Science of Complexity in Everyday Life*. Philadelphia, Basic Books, 288 pp. [The process of "self-organization" and of "swarm intelligence" in living organisms, from fish to ants to human beings.]

Fisher M., Goddu M. K., Keil F. C. 2015. Searching for Explanations: How the Internet Inflates Estimates of Internal Knowledge. *Journal of Experimental Psychology: General* doi : http://dx.doi.org/10.1037/xge0000070. [This article shows that searching for information online leads to an increase in self-assessed knowledge as people mistakenly think they have more knowledge "in the head," even seeing their own brains as more active as depicted by functional MRI (fMRI) images.]

Flatz G. 1987. Genetics of Lactose Digestion in Humans. *Advances in Human Genetics* 16: 1-77. [This article is a review of the causes and distribution of the dimorphism of lactase activity in human adults.]

Flynn J. R. 1987. Massive IQ gains in 14 nations: what IQ tests really measure. *Psychological Bulletin* 101:171-191 doi:10.1037/0033-2909.101.2.171. [This article argues that IQ tests do not measure intelligence but rather a correlate with a weak causal link to intelligence.]

Fonseca-Azevedo K., Herculano-Houzel S. 2012. Metabolic constraint imposes tradeoff between body size and number of brain neurons in human evolution. *Proceedings of the National Academy of Sciences* 109(45): 18571-18576. [This article shows (i)that brain size is directly linked to the number of neurons in a brain; and (ii), that the number of neurons is directly correlated to the amount of energy (or calories) needed to feed a brain.]

Gaser C., Schlaug G**.** 2003. Brain Structures Differ between Musicians and Non-Musicians. *The Journal of Neuroscience* 23(27): 9240-9245. [This article shows structural adaptations in response to long-term skill acquisition in different brain regions when comparing professional musicians with a matched group of amateur musicians and non-musicians.]

Gelfand M. J., Raver J. L., Nishii L. *et al.* 2015. Differences Between Tight and Loose Cultures: A 33-Nation Study. *Science* 332: 1100-1104. [This article illustrates the differences between cultures that are tight (have many strong norms and a low tolerance of deviant behavior) versus loose (have weak social norms and a high tolerance of deviant behavior.]

Gendron M., Lindquist K. A., Barsalou L., Barrett L. F. 2012. Emotion words shape emotion percepts. *Emotion* 12(2): 314-325. [According to the Whorfian view (see glossary), this article demonstrates that the exact same face was encoded differently when a word was accessible versus when it was not.]

Gibbons A. 2006. There's More Than One Way to Have Your Milk and Drink It, Too. *Science* 314: 1672. [A brief report on research on lactose tolerance.]

Gibbons A. 2010. Tracing Evolution's Recent Fingerprints. *Science* 329: 740-742. [An article about the genes that helped humans adapt to new climates, diseases, and diets, exposing how evolution works.]

Gold J., Gold I. 2015. *Suspicious Minds. How Culture Shapes Madness*. New York, Free Press (Simon and Schuster), 351 pp. [A theory for understanding psychosis through a social lens.]

Gordon P. 2004. Numerical Cognition Without Words: Evidence from Amazonia. *Science* 306: 496-499. [According to the Whorfian view (see glossary), this article shows that numerical cognition is clearly affected by the lack of a counting system in the language.]

Goren C. C., Sarty M., Wu P.Y.K. 1975. Visual following and pattern discrimination of face-like stimuli by newborn infants. *Pediatrics* 56: 544-549. [The preference for the proper face stimulus by infants who had not seen a real face prior to testing suggests that an unlearned or "evolved" responsiveness to faces may be present in human neonates.]

Granjean P. 2013.. Oxford, Oxford University Press, 2013, 232 pp. [This book explains how industrial chemicals are causing a silent pandemic of chemical brain drain.]

Greenfeld L. 2013. *Mind, Modernity, Madness. The Impact of Culture on Human Experience*. Cambridge, MA, Harvard University Press, 688 pp. [In this book, the author argues that madness is a culturally constituted malady.]

Greenhill Stuart D., Juczewski Konrad, de Haan Annelies M., Seaton Gillian, Fox Kevin, Hardingham Neil R. 2015. Adult cortical plasticity depends on an early postnatal critical period. *Science* 349 : 424-427 This article shows that the development of the cerebral cortex is influenced by sensory experience during distinct phases of postnatal development known as critical periods.

Grossmann I., Ellsworth P. C., Hong Y. -Y. 2011. Culture, attention and emotion. *Journal of Experimental Psychology*: *General* 141(1): 31-36. [This article provides experimental evidence for cultural influence on one of the most basic elements of emotional processing: attention to positive versus negative stimuli.]

Gutchess A. H. 2014. Plasticity of the aging brain: New directions in cognitive neuroscience. *Science* 346: 579-582. [This article shows that aging of the brain, amidst interrelated behavioral and biological changes, is as complex and idiosyncratic as the brain itself, qualitatively changing over the life span.]

Hair N.L., Hanson J.L., Wolfe B.L., Pollak S.D. 2015. Association of child poverty, brain development, and academic achievement. *JAMA Pediatrics* 169(9): 822-829. [This article discusses the effect of poverty and early childhood environments on brain development.]

Halloy A. 2015. *Divinités incarnées. L'apprentissage de la possession dans un culte afro-brésilien*. Paris, Petra, 412 pp. [This book suggests that a major part of possession comes from a form of emotional learning.]

Han S., Northoff G. 2008. Culture-sensitive neural substrates of human cognition: a transcultural neuroimaging approach. *Nature Reviews Neuroscience* 9: 646-654. [Recent transcultural neuroimaging studies have demonstrated that one's cultural background can influence the neural activity that underlies both high- and low-level cognitive functions.]

Han S., Northoff G., Vogeley K. *et al.* 2013. A Cultural Neuroscience Approach to the Biosocial Nature of the Human Brain. *Annual Review of Psychology* 64(1): 335-359. [This review describes the origin, aims, and methods of Cultural Neuroscience (see glossary) as well as its conceptual framework and major findings.]

Hancock A. M., Witonsky D. B., Ehler E., Alkorta-Aranburu G., Beall C. Gebremedhin A., Sukernik R., Utermann G., Pritchard J., Coop G., Di Rienzo A. 2010. Human adaptations to diet, subsistence, and ecoregion are due to subtle shifts in allele frequency. *Proceedings of the National Academy of Sciences* 107(suppl. 2): 8924-8930. [This article discusses the genetic basis of human subsistence strategies to exploit an exceptionally broad range of ecoregions and dietary components.]

Hanushek E.A., Woessmann L. 2015. *The Knowledge Capital of Nations: Education and the Economics of Growth*. Cambridge, MA, MIT Press, 280 pp. [The authors contend that the cognitive skills of the population—which they term the "knowledge capital" of a nation—are essential to long-run prosperity.]

Hawks J., Wang E. T., Cochran G. M., Harpending H. C., Moyzis R. K. 2007. Recent acceleration of human adaptive evolution. *Proceedings of the National Academy of Sciences* 104(52): 20753-20758. [This article discusses the extraordinarily rapid recent genetic evolution of our species.]

Heard E., Martienssen R.A. 2014. Transgenerational Epigenetic Inheritance: Myths and Mechanisms. *Cell* 157(1): 95-109. [This article discusses the issue of the inheritance of epigenetic characters.]

Hehemann J.-H., Correc G., Barbeyron T., Helbert W., Czjzek M., Michel G. 2010. Transfer of carbohydrate-active enzymes from marine bacteria to Japanese gut microbiota. *Nature* 464: 908-912. [This article shows how the diversity in gut microbiota evolved by acquiring new genes from microbes living outside the gut.]

Heijmans B.T., Tobi E.W., Stein A.D., Putter H., Blauw G.J., Susser E.S., Slagboom P.E., Lumey L.H. 2008. Persistent epigenetic differences associated with prenatal exposure to famine in humans. *Proceedings of the National Academy of Sciences* 105(44): 17046-17049. [This article shows that individuals who were prenatally exposed to famine during the Dutch Hunger Winter in 1944–45 had, 6 decades later, less DNA methylation (see glossary) of the imprinted IGF2 gene compared with their unexposed, same-sex siblings.]

Henrich J. 2016. *The Secret of Our Success: How Culture Is Driving Human Evolution, Domesticating Our Species, and Making Us Smarter*. Princeton, Princeton University Press, 445 pp. [This book explains whiy culture is essential for understanding human evolution.]

Henrich J. 2004. Demography and Cultural Evolution: How Adaptive Cultural Processes Can Produce Maladaptive Losses-The Tasmanian Case. *American Antiquity* 69(2): 197-214. **[**This article discusses the general question of how human cognition and social interaction can generate both adaptive cultural evolution and maladaptive losses of culturally acquired skills.]

Henrich J., Heine S. J., Norenzayan A. 2010. The weirdest people in the world? *Behavioral and Brain Sciences* 1-75 doi:10.1017/S0140525X0999152X. [This review of the comparative database from across the behavioral sciences suggests both that there is substantial variability in experimental results across populations and that WEIRD (Western, Educated, Industrialized, Rich, and Democratic) subjects are particularly unusual compared with the rest of the species.]

Henrich J., Henrich N. 2007. *Why Humans Cooperate: A Cultural and Evolutionary Explanation*. Oxford-New York, Oxford University Press, 272 pp. [This book discusses cooperation among humans, one of the keys to our great evolutionary success.]

Herdener M., Esposito F., di Salle F. *et al.* 2010. Musical Training Induces Functional Plasticity in Human Hippocampus. *The Journal of Neuroscience* 30(4): 1377-1384. [This article provides direct evidence for functional changes of the adult hippocampus in humans related to musical training.]

Herrmann E., Call J., Hernàndez-Lloreda M. V., Hare B., Tomasello M. 2007. Humans Have Evolved Specialized Skills of Social Cognition: The Cultural Intelligence Hypothesis. *Science* 317: 1360-1366. [This article shows that the children and chimpanzees had very similar cognitive skills for dealing with the physical world but that the children had more sophisticated cognitive skills than either of the ape species for dealing with the social world.]

Heyes C. 2012. Grist and mills: on the cultural origins of cultural learning. *Philosophical Transactions of the Royal Society B: Biological Sciences* 367: 2181-2191. [This article shows that through social interaction in the course of development, we not only acquire facts about the world and how to deal with it (grist), we also build the cognitive processes that make 'fact inheritance' possible (mills).]

Heyes C. M., Frith C. D. 2014. The cultural evolution of mind reading. *Science* 344: 1357. [This article suggests that infants are equipped with neurocognitive mechanisms that yield accurate expectations about behavior ("implicit" mind reading), whereas "explicit" mind reading, like literacy, is a culturally inherited skill, passed from one generation to the next by verbal instruction.]

Hohmann G., Fruth B. 2003. Culture in Bonobos? Between-species and within-species variation in behavior. *Current Anthropology* 44(4): 563-571. [This article discusses the use of the term "culture" in non-humans primates.]

Holden C., Mace R. 1997. Phylogenetic analysis of the evolution of lactose digestion in adults. *Human Biology* 69(5): 605-628. [This article supports the hypothesis that high adult lactose digestion capacity is an adaptation to dairying but does not support the hypotheses that lactose digestion capacity is additionally selected for either at high latitudes or in highly arid environments.]

Hostinar C. E., Stellern S. A., Schaefer C., Carlson S. M., Gunnar M. R. 2012. Associations between early life adversity and executive function in children adopted internationally from orphanages. *Proceedings of the National Academy of Sciences* 109 (Sup. 2):17208-17212. [This article provides evidence that early life adversity is associated with significant reductions in executive function performance.]

Huerta-Sánchez E., DeGiorgio M., Pagani L. *et al.* 2013. Genetic Signatures Reveal High-Altitude Adaptation in a Set of Ethiopian Populations. *Molecular Biology and Evolution* 30(8): 1877-1888. [This article supports the view that Ethiopian, Andean, and Tibetan populations living at high altitude have adapted to hypoxia differently, with convergent evolution affecting different genes from the same pathway.]

Huerta-Sanchez E., Jin X., Asan *et al.* 2014. Altitude adaptation in Tibetans caused by introgression of Denisovan-like DNA. *Nature* 512: 194-197. [This article illustrates that admixture with other hominin species has provided genetic variation that helped humans to adapt to new environments.]

Huffman M.A. 1984. Stone play of Macaca fuscata in Arashuyama B troop: transmission of a non-adaptative behavior. *Journal of Human Evolution* 13: 725-735. [This article shows how a non-adaptive behavior initially diffused among younger individuals was then later transmitted in form of tradition from these individuals to their offspring or younger sibs and playmates.]

Hünemeier T., Gómez-Valdés J., Ballesteros-Romero M. *et al.* 2012. Cultural diversification promotes rapid phenotypic evolution in Xaványte Indians. *Proceedings of the National Academy of Sciences* 109(1): 73-77. [This article demonstrates how human groups deriving from a recent common ancestor can experience variable paces of phenotypic divergence, probably as a response to different cultural or social determinants.]

Hutchins E. 1995. *Cognition in the wild*. Cambridge, MA, MIT Press, 408 pp. [An account of how anthropological methods can be combined with cognitive theory to produce a new reading of cognitive science.]

Hyde K. L., Lerch J., Norton A. *et al.* 2009. Musical Training Shapes Structural Brain Development. *The Journal of Neuroscience* 29(10): 3019-3025. [These findings shed light on brain plasticity and suggest that structural brain differences in adult experts (whether musicians or experts in other areas) are likely due to training-induced brain plasticity.]

Ilg R., Wohlschläger A. M., Gaser C. *et al.* 2008. Gray Matter Increase Induced by Practice Correlates with Task-Specific Activation: A Combined Functional and Morphometric Magnetic Resonance Imaging Study. *The Journal of Neuroscience* 28: 4210-4215. [This article confirms that short-term gray matter signal increase corresponds to task-specific processing.]

Jacquet P. O., Baumard N., Chevallier C. 2016. Does culture get embrained? *Proceedings of the National Academy of Sciences* 113(21): E2873. [This article discusses Mu *et al.*'s article (2015): see reference below).]

Johnson M., Dziurawiec S., Ellis H., Morton J. 1991. Newborns' preferential tracking of face-like stimuli and its subsequent decline. *Cognition* 4: 1-19. [This article confirms that newborn infants will follow a slowly moving schematic face stimulus with their head and eyes further than they will follow scrambled faces or blank stimuli.]

Jones N. 2011. Human influence comes of age. *Nature* 473: 133. [This article discusses the humanity's profound impact on this planet (see "Anthropocene" in the glossary).]

Joshi P. K., Esko T., Mattsson H. *et al.* 2016. Directional dominance on stature and cognition in diverse human populations. *Nature* 523: 459-462. [This study provides evidence that increased stature and cognitive function have been positively selected in human evolution.]

Juonala M., Pulkki-Råback L., Elovainio M. *et al.* 2016. Childhood psychosocial factors and coronary artery calcification in adulthood: The cardiovascular risk in young finns study. *JAMA Pediatrics* 170(5): 466-472. [In this article, the authors observe an independent association between childhood psychosocial well-being and reduced coronary artery calcification in adulthood.]

Kanai R., Bahrami B., Roylance R., Rees G. 2012. Online social network size is reflected in human brain structure. *Proceedings of the Royal Society B: Biological Sciences* 279(1732): 1327-1334. [This article demonstrates that the size of an individual's online social network is closely linked to focal brain structure implicated in social cognition.]

Kang D.-H., Jo H. J., Jung W. H. *et al.* 2013. The effect of meditation on brain structure: cortical thickness mapping and diffusion tensor imaging. *Social Cognitive and Affective Neuroscience* 8(1): 27-33. [This article suggests that long-term meditation induces structural differences in both gray and white matter.]

Katz S. H., Schall J. 1979. Fava Bean Consumption and Biocultural Evolution. *Medical Anthropology* 3(4): 459-476. [This biocultural evolutionary approach to dietary behavior provides a basis for examination of fava bean consumption in the circum-Mediterranean region.]

Kaufman J., Yang B.Z., Douglas-Palumberi H., Grasso D., Lipschitz D., Houshyar S., Krystal J. H., Gelernter J. 2006. Brain-derived neurotrophic factor- 5-HTTLPR gene interactions and environmental modifiers of depression in children. *Biological Psychiatry* 59: 673-680. [This is the first investigation to demonstrate a gene-by-gene interaction conveying vulnerability to depression. The article also shows a protective effect of social supports in ameliorating genetic and environmental risk for psychopathology.]

Kay P., Regier T. 2003. Resolving the Question of Color Naming Universals. *Proceedings of the National Academy of Sciences* 100(15): 9085-9089. [This article shows that strong universal tendencies in color naming exist across both sorts of language, see "Whorfian perspective" in the glossary.]

Keverne E. B., Pfaff D. W., Tabansky I. 2015. Epigenetic changes in the developing brain: Effects on behavior. *Proceedings of the National Academy of Sciences* 112(22): 6789-6795. [This article discusses the topic of epigenetic chemistry and behavioral neuroscience.]

Kidd D. C., Castano E. 2013. Reading Literary Fiction Improves Theory of Mind. *Science*. 342: 377-380. [This article suggests that Theory of Mind (see glossary) may be influenced by engagement with works of art.]

Kim-Cohen J., Gold A.L. 2009. Measured Gene-Environment Interactions and Mechanisms Promoting Resilient Development. *Current Directions in Psychological Science* 18(3): 138-142. [This article summarizes advances toward greater specification of "gene–environment interactions" mechanisms, including genetic and environmental moderation of "gene–environment interactions" effects and imaging genomics that provide clues regarding resilience processes in development.]

Kimberly N. G., Houston S. M., Brito N. H. *et al.* 2015. Family income, parental education and brain structure in children and adolescents. *Nature Neuroscience* 18: 773-778. [This article shows that poverty may affect the growth of children's brains.]

Kitayama S., Uskul A. 2011. Culture, mind, and the brain: Current evidence and future directions. *Annual Review* of *Psychology* 62: 419-449. [This article proposes a new model of neuro-culture interaction by hypothesizing that the brain serves as a crucial site that accumulates effects of cultural experience, insofar as neural connectivity is likely modified through sustained engagement in cultural practices.]

Kolb B., Mychasiuk R., Muhammad A. *et al.* 2012. Experience and the developing prefrontal cortex. *Proceedings of the National Academy of Sciences* 109(S2): 17186-17193. [This article shows how early experiences influence prefrontal development and

behavior.]

Kovács A. M., Mehler J. 2009a. Cognitive gains in 7-month-old bilingual infants. *Proceedings of the National Academy of Sciences* 106(16): 6556-6560. [This article shows that processing representations from 2 languages leads to a domain-general enhancement of the cognitive control system well before the onset of speech.]

Kovács A. M., Mehler J. 2009b. Flexible Learning of Multiple Speech Structures in Bilingual Infants. *Science* 325: 611-612. [This article shows show that preverbal 12-month-old bilingual infants have become more flexible at learning speech structures than monolinguals.]

Kraus N., Slater J., Thompson E. C. 2014. Music Enrichment Programs Improve the Neural Encoding of Speech in At-Risk Children. *The Journal of Neuroscience* 34(36): 11913-11918. [This article shows that music training aids speech processing.].

Kroeber A.L., Kluckhohn C. 1952. Culture: A critical review of concepts and definitions. *Papers of the Peabody Museum of American Archeology and Ethnology* 47(1), VIII + 223 pp. Cambridge, MA, Harvard University Press. [This text is a critical review of definitions and a general discussion of culture theory.]

Kühn S., Lorenz R., Banaschewski T. *et al.* 2014. Positive Association of Video Game Playing with Left Frontal Cortical Thickness in Adolescents. *PLoS ONE* 9(3): e91506. [This article shows that time spent playing video games is positively associated with brain thickening in the left dorsolateral prefrontal cortex and left frontal eye fields.]

Kundakovic M., Gudsnuk K., Herbstman J.B., Tang D., Perera F.P., Champagne F.A. 2015. DNA methylation of BDNF as a biomarker of early-life adversity. *Proceedings of the National Academy of Sciences* 112(22): 6807-6813. [This article discusses the behavioral vulnerability induced by early-life environmental exposure.]

Kurvers R. H. J. M., Wolf M., Naguib M., Krause J. 2015. Self-organized flexible leadership promotes collective intelligence in human groups. Royal Society Open Science 2(12) doi 10.1098/rsos.150222. [This article shows show that groups can self-organize according to the information accuracy of their members, thereby promoting collective intelligence.]

Laland K. N., Odling-Smee J., Myles S. 2010. How culture shaped the human genome: bringing genetics and the human sciences together. *Nature Reviews Genetics* 11: 137-148. [This article collates data highlighting the considerable potential for cross-disciplinary exchange to provide novel insights into how culture has shaped the human genome.]

Laland K. N., Reader S. M. 1999. Foraging innovation in the guppy. *Animal Behaviour* 57(2): 331-340. [This article shows differences in foraging innovation in guppies.]

Langergraber K. E., Boesch C., Inoue E., Inoue-Murayama M., Mitani J. C., Nishida T., Pusey A., Reynolds V., Schubert G., Wrangham R. W., Wroblewski E., Vigilant L. 2010. Genetic and 'cultural' similarity in wild chimpanzees. *Proceedings of the Royal Society B* published online 18 August 2010 doi: 10.1098/rspb.2010.1112. [This article indicates that genetic dissimilarity cannot be eliminated as playing a major role in generating group differences in chimpanzee behaviour.]

Lansing J. S., Cox M.P., Downey S.S., Gabler B.M., Hallmark B., Karafet T.M., Norquest P., Schoenfelder J.W., Sudoyo H., Watkins J.C., Hammer M.F. 2007. Coevolution of languages and genes on the island of Sumba, eastern Indonesia. *Proceedings of the National Academy of Sciences* 104(41): 16022-16026. [This article proposes a model to explain linguistic and demographic coevolution at fine spatial and temporal scales.]

Lawson D. W., James S., Ngadaya E., Ngowi B., Mfinanga S. G. M., Borgerhoff M. M. 2015. No evidence that polygynous marriage is a harmful cultural practice in northern Tanzania. *Proceedings of the National Academy of Sciences* 112(45): 13827-13832. [This article highlights the need for improved, culturally sensitive measurement tools and appropriate scales of analysis in studies of polygyny and other purportedly harmful practices.]

Lende D. H., Downey G. (eds). 2012. *The Encultured Brain. An Introduction to Neuroanthropology*. Cambridge MA, MIT Press, 448 pp. [This book provides a foundational text for neuroanthropology, offering basic concepts and case studies at the intersection of brain and culture.]

Lévi-Strauss C. 1973. *Anthropologie structurale deux*. Paris, Plon, 450 pp. [This book introduces readers to the methods of structural anthropology while affording a glimpse into the mind of one of the foremost anthropologists of our time.]

Lindenberger U. 2014. Human cognitive aging: Corriger la fortune? *Science* 346: 572-578. [This article suggests that leading an intellectually challenging, physically active, and socially engaged life may mitigate losses and consolidate gains.]

Livingstone F.B. 1958. Anthropological Implications of Sickle Cell Gene Distribution in West Africa. *American Anthropologist* 60: 533-562. [The purpose of this article is to show how the distribution of the sickle cell gene in West Africa is the result of the interaction of two factors, selection and gene flow.]

Livneh Y., Feinstein N., Klein M., Mizrahi A. 2009. Sensory Input Enhances Synaptogenesis of Adult-Born Neurons. *The Journal of Neuroscience* 29(1): 86-97. [This article provides evidence for an activity-based mechanism that enhances synaptogenesis of adult-born periglomerular neurons during their initial phases of development.]

Lederbogen F., Kirsch P., Haddad L. *et al.* 2011. City living and urban upbringing affect neural social stress processing in humans. *Nature* 474: 498-501. [This article shows that urban upbringing and city living have dissociable impacts on social evaluative stress processing in humans.]

Lledo P.M., Alonso M., Grubb M.S. 2006. Adult neurogenesis and functional plasticity in neuronal circuits. *Nature Reviews | Neuroscience* 7: 179-193. [This article discusses the plastic mechanism by which the brain's performance can be optimized for a given environment.]

Luby J. L., Belden A., Harms M. P., Tillman R., Barch D. M. 2016. Preschool is a sensitive period for the influence of maternal support on the trajectory of hippocampal development. *Proceedings of the National Academy of Sciences* 113(20): 5742-5747. [This article suggest that enhancing early childhood maternal support fosters healthy childhood brain development and emotion functioning.]

Luby J., Belden A., Botteron K. *et al.* 2013. The effects of poverty on childhood brain development: The mediating effect of caregiving and stressful life events. *JAMA Pediatrics* doi: 10.1001/jamapediatrics.2013.3139. [This article shows that exposure to poverty in early childhood materially impacts brain development at school age.]

Lupyan G., Ward E. J. 2013. Language can boost otherwise unseen objects into visual awareness. *Proceedings of the National Academy of Sciences* 110(35): 14196-14201. [This article suggests that facilitated detection of invisible objects due to language occurs at a perceptual rather than semantic locus.]

Lutgendorf S.K., Degeest K., Sung C.Y., Arevalo J.M., Penedo F., Lucci J.III, *et al.* 2009. Depression, social support, and beta-adrenergic transcription control in human ovarian cancer. *Brain, Behavior, and Immunity* 23: 176-183. [This article shows that genome-wide transcriptional profiles are significantly altered in tumors from patients with high behavioral risk profiles, and it identifies beta-adrenergic signal transduction as a likely mediator of those effects.]

Maguire E. A., Gadian D. G., Johnsrude I. S. *et al.* 2000. Navigation-related structural change in the hippocampi of taxi drivers. *Proceedings of the National Academy of Sciences* 97(8): 4398-4403. [This article shows that the posterior hippocampus stores a spatial representation of the environment and can expand regionally to accommodate elaboration of this representation in people with a high dependence on navigational skills.]

Majid A., Bowerman M., Kita S., Haun D.B.M., Levinson S.C. 2004. Can language restructure cognition? The case for space. *Trends in Cognitive Sciences* 8(3): 108-114. [This article argues that language can play a significant role in structuring, or restructuring, a domain as fundamental as spatial cognition.]

Majid A., Burenhult N. 2014. Odors are expressible in language, as long as you speak the right language. *Cognition* 130(2): 266-270. [This article shows that the long-held assumption that people are bad at naming smells is not universally true.]

Mampe B., Friederici A. D., Christophe A., Wermke K. 2009. Newborns' Cry Melody Is Shaped by Their Native Language. *Current Biology* 19(23): 1994-1997. [This article shows an influence of the surrounding speech prosody on newborns' cry melody.]

Mani A., Mullainathan S. *et al.* 2013. Poverty Impedes Cognitive Function. *Science* 341: 976-980. [This article shows that poverty reduces cognitive capacity, and it suggests that this is because poverty-related concerns consume mental resources, leaving less for other tasks.]

Manly J.J., Byrd D., Touradji P., Sanchez D., Stern Y. 2004. Literacy and cognitive change among ethnically diverse elders. *International Journal of Psychology* 39(1): 47-60. [This article suggests that literacy has a profound effect on neuropsychological measures across verbal and nonverbal domains, and that this effect is independent of other demographic and experiential factors such as age, years of education, sex, ethnicity, and language use.]

Mathieson I., Lazaridis I., Rohland N. *et al.* 2015. Genome-wide patterns of selection in 230 ancient Eurasians. *Nature* 528: 499-503 [Among Europe's first farmers, this article detects selection at loci associated with diet, pigmentation and immunity, and two independent episodes of selection on height.]

Mathew S., Perreault C. 2015. Behavioural variation in 172 small-scale societies indicates that social learning is the main mode of human adaptation. *Proceedings of the Royal Society of London B: Biological Sciences* 282(1810): 10.1098/rspb.2015.0061. [The authors measure the relative contribution of environment and cultural history in explaining the behavioural variation of 172 Native American tribes at the time of European contact.They find that the effect of cultural history is typically larger than that of environment.]

McGowan P. O., Sasaki A., D'Alessio A.C., Dymov S., Labonté B., Szyf M., Turecki G., Meaney M.J. 2009. Epigenetic regulation of the glucocorticoid receptor in human brain associates with childhood abuse. *Nature Neuroscience* 12(3): 342-348. [This article translates previous results from rat to humans and suggests a common effect of parental care on the epigenetic regulation of hippocampal glucocorticoid receptor expression.]

McGrew W. C., Marchant L.F., Scott S.E., Tutin C.E.G. 2001. Intergroup Differences in a Social Custom of Wild Chimpanzees: The Grooming Hang-Clasp of the Mahale Mountains. *Current Anthropology* 42(1): 148-153. [This article reports the first case of a difference in social custom between neighboring groups of chimpanzees.]

McGrew W.C. 1998. Culture in Nonhuman Primates? *Annual Review of Anthropology* 27: 301-328. [This article discusses the topic of cultural primatology.]

McGrew W.C. 2010. Chimpanzee Technology. *Science* 328: 579-580. [This article argues that chimpanzees are the only nonhuman animal species known to make and use a wide range of complex tools.]

McLaughlin K. A., Sheridan M. A., Tibu F. *et al.* 2015. Causal effects of the early caregiving environment on development of stress response systems in children. *Proceedings of the National Academy of Sciences* 112(18): 5637-5642. [This article provides evidence for a causal link between the early caregiving environment and stress response system reactivity in humans with effects that differ markedly from those observed in rodent models.]

McNamara T. P., Shelton A.L. 2003. Cognitive maps and the hippocampus. *Trends in Cognitive Sciences* 7(8): 333-335. [This article discusses the neural basis of route following and wayfinding in humans.]

Mechelli A., Crinion J. T., Noppeney U. *et al.* 2004. Neurolinguistics: Structural plasticity in the bilingual brain. *Nature* 431: 757. [This article confirms that the human brain changes structurally in response to environmental demands.]

Mercader J., Barton H., Gillespie J., Harris J., Kuhn S., Tyler R., Boesch C. 2007. 4,300-Year-old chimpanzee sites and the origins of percussive stone technology. *Proceedings of the National Academy of Sciences* 104(9): 3043-3048. [This article suggests that percussive material culture could have been inherited from a common human–chimpanzee clade, rather than invented by hominins, or have arisen by imitation, or resulted from independent technological convergence.]

Mitchell C., Hobcraft J., McLanahan S. S. 2014. Social disadvantage, genetic sensitivity, and children's telomere length. *Proceedings of the National Academy of Sciences* 111(16): 5944-5949. [This article documents a gene–social environment interaction for telomere length, a biomarker of stress exposure.]

Miller G. 2010. The Seductive Allure of Behavioral Epigenetics. *Science* 329: 24-27. [This article presents the field of Behavioral Epigenetics (see glossary).]

Miller G. E., Chen E., Fok A. K., Walker H., Lim A., Nicholls E. F., Cole S., Kobor M.S. 2009. Low early-life social class leaves a biological residue manifested by decreased glucocorticoid and increased proinflammatory signaling *Proceedings of the National Academy of Sciences* 106(34): 14716-14721. [This article suggests that low early-life socioeconomic status programs a defensive phenotype characterized by resistance to glucocorticoid signaling, which in turn facilitates exaggerated adrenocortical and inflammatory responses.]

Milner G. 2016. *Pinpoint: How GPS is Changing Technology, Culture, and Our* Minds. W. W. New York – London, Norton & Company, 336 pp. **[**This book examines the different ways humans have understood physical space, delves into the neuroscience of cognitive maps, and questions GPS's effect on our culture and on human cognition.]

Morgan B. J., Abwe E.E. (2006). Chimpanzees use stone hammers in Cameroon. *Current Biology* 16(16): R632-R633. [This article reports the first observations of nut-cracking for *Pan troglodytes vellerosus*, a subspecies apparently restricted to western Cameroon and eastern and southern Nigeria.]

Mu Y., Kitayama S., Han S., Gelfand M. J. 2015. How culture gets embrained: Cultural differences in event-related potentials of social norm violations. *Proceedings of the National Academy of Sciences* 112(50): 15348-15353. [This article provides the evidence for the neurobiological foundations of social norm violation detection and its variation across cultures.]

Muggleton N. G., Banissy M. J. 2014. Culture and Cognition. *Cognitive Neuroscience* 5(1): 1-2. [This issue presents empirical papers investigating diverse categories of potential culturally related effects as well as a review article, all of which provide timely updates of the current state of knowledge in the area of Cognition & Culture.]

Mullen M. K., Yi S. 1995. The cultural context of talk about the past: Implications for the development of autobiographical memory. *Cognitive Development*, 10 (3): 407-419. [This article supports the theory that early linguistic experience may be related to the development of autobiographical memory.]

Muthukrishna M, Shulman B. W., Vasilescu V., Henrich J. 2014. Sociality influences cultural complexity. *Proceedings of the Royal Society B* 281: 20132511. [This article supports theoretical predictions linking sociality to cumulative cultural evolution.]

Muthukrishna M, Henrich J. 2016. Innovation in the collective brain. *Philosophical Transactions of the Royal Society of London B: Biological Sciences* 371(1690): doi 10.1098/rstb.2015.0192. [In this article, the authors argue that rates of innovation are heavily influenced by (i) sociality, (ii) transmission fidelity, and (iii) cultural variance.]

Nemeroff C. B. 2004. Neurobiological consequences of childhood trauma. *Journal of Clinical Psychiatry* 65 [Suppl 1]: 18-28. [A review of the preclinical and clinical studies evaluating the consequences of early-life stress.]

Nestler E.J. 2016. Transgenerational Epigenetic Contributions to Stress Responses: Fact or Fiction? *PLoS Biology* 14(3): e1002426 [This article provides an overview of the multiple meanings of the term epigenetic, and discusses the challenges of studying epigenetic contributions to stress susceptibility

Nettle D. 2009. Beyond nature versus culture: cultural variation as an evolved characteristic. *Journal of the Royal Anthropological Institute* 15: 223-240. [This article suggests a high degree of mutual compatibility and potential gains from trade between the social and biological sciences.]

Neville H. J., Stevens C., Pakulak E. *et al.* 2013. Family-based training program improves brain function, cognition, and behavior in lower socioeconomic status preschoolers. *Proceedings of the National Academy of Sciences* 110(29): 12138-12143. [This article suggests that a training program in attention for 3- to 5-year-olds and their families could help boost brain activity and narrow the academic achievement gap between low- and high-income students.]

Nisbett R.E., Peng K., Choi I., Norenzayan A. 2001. Culture and systems of thought: holistic versus analytic cognition. *Psychological Review* 108: 291-310. [This article proposes a theory of how systems of thought arise on the basis of differing cultural practices and argues that the theory accounts for substantial differences in East Asian and Western thought processes.]

Noad M. J., Cato D.H., Bryden M.M., Jenner M.N., Jenner K.C.S. 2000. Cultural revolution in whale songs. *Nature* 408: 537. [This article shows that humpbacks have picked up a catchy tune sung by immigrants from a distant ocean.]

Nowak M. A., with Highfield R. 2011. *SuperCooperators: Altruism, Evolution, and Why We Need Each Other to Succeed.* New York, Free Press, 354 pp. [This book explains why cooperation, not competition, has always been the key to the evolution of complexity.]

O'Brien M. J., Laland K. N. 2012. Genes, Culture, and Agriculture: An Example of Human Niche Construction. *Current Anthropology* 53(4): 434-470. [This article discusses niche construction theory and gene-culture coevolutionary theory (see glossary for these two terms).]

Oberlander T. F., Weinberg J., Papsdorf M., Grunau R., Misri S., Devlin A. M. 2008. Prenatal exposure to maternal depression, neonatal methylation of human glucocorticoid receptor gene (NR3C1) and infant cortisol stress responses. *Epigenetics* 3(2):97-106 doi: 10.4161/epi.3.2.6034. [This article shows that methylation (see glossary) status of the human NR3C1 gene in newborns is sensitive to prenatal maternal mood and may offer a potential epigenetic process (see "Epigenome" in the glossary) that links antenatal maternal mood and altered hypothalamicpituitary-adrenal stress reactivity during infancy.]

Okbay A., Beauchamp J.P., Fontana M.A. *et al.* 2016. Genome-wide association study identifies 74 loci associated with educational attainment. *Nature* 533 : 539-542 [This article identifies 74 genome-wide significant lociassociated with the number of years of schooling completed.]

Olmstead M. C., Kuhlmei V. A. 2015. *Comparative Cognition.* Cambridge, Cambridge University Press. [Integrating developments from psychology, ethology and neuroscience, this book is an undergraduate introduction to cognitive processes across species.]

Oota H., Settheetham-Ishida W., Tiwawech D., Ishida T., Stoneking M. 2001. Human mtDNA and Y-chromosome variation is correlated with matrilocal versus patrilocal résidence. *Nature Genetics* 29(1): 20-21. [This article shows that genetic diversity in matrilocal and patrilocal groups (see glossary) has a striking correlation with residence pattern, supporting the role of sex-specific migration in influencing human genetic variation.]

Ophir E., Nass C. *et al.* 2009. Cognitive control in media multitaskers. *Proceedings of the National Academy of Sciences* 106(37): 15583-15587. [This article shows that heavy media multitaskers are more susceptible to interference from irrelevant environmental stimuli and from irrelevant representations in memory.]

Özgen E., Davies I. R. L. 2002. Acquisition of categorical color perception: A perceptual Learning approach to the linguistic relativity hypothesis. *Journal of Experimental Psychology: General* 131: 477–493. [This article shows that language may shape color perception and suggests a plausible mechanism for the linguistic relativity hypothesis (see "Whorfian perspective" in the glossary).]

Pagel M. 2012. *Wired for Culture. Origins of the Human Social Mind.* New York, W.W. Norton & Company, 432 pp. [This book shows how an innate propensity to contribute and conform to the culture of our birth not only enabled human survival and progress in the past but also continues to influence our behavior today.]

Pagel M., Mace R. 2004. The cultural wealth of nations. *Nature* 428: 275-278. [This article discusses the following question: why, when the human race shows comparatively little genetic variation, are cultural differences so widespread and enduring?]

Park D.C., Reuter-Lorenz P. 2009. The Adaptive Brain: Aging and Neurocognitive Scaffolding. *Annual Review of Psychology* 60: 173-96. [This article provides an integrative view of the aging mind, suggesting that pervasive increased frontal activation with age is a marker of an adaptive brain that engages in compensatory scaffolding in response to the challenges posed by declining neural structures and function.]

Partanen E., Kujala T., Näätänen R., Liitola A., Sambeth A., Huotilainen M. 2013. Learning-induced neural plasticity of speech processing before birth. *Proceedings of the National Academy of Sciences* 110(37): 15145-15150. [This article shows that prenatal experiences have a remarkable influence on the brain's auditory discrimination accuracy, which may support, for example, language acquisition during infancy.]

Perry G. H., Dominy N.J., Claw K.G., Lee A.S., Fiegler H., Redon R., Werner J., Villanea F.A., Mountain J.L., Misra R., Carter N.P., Lee C., Stone A.C. 2007. Diet and the evolution of human amylase gene copy number variation. *Nature Genetics* 39(10): 1256-1260. [An example of positive selection on a copy number–variable geni, one of the first discovered in the human genome.]

Petanjek Z., Judas M., Simic G. *et al.* 2011. Extraordinary neoteny of synaptic spines in the human prefrontal cortex. *Proceedings of the National Academy of Sciences* 108(32): 13281-13286. [This article shows an extraordinarily long phase of developmental reorganization of cortical neuronal circuitry, which has implications for understanding the effect of environmental impact on the development of human cognitive and emotional capacities as well as the late onset of

human-specific neuropsychiatric disorders.]

Petersson K. M., Silva C., Alexandre Castro-Caldas A., Ingvar M., Reis A. 2007. Literacy: A cultural influence on functional left-right differences in the inferior parietal cortex. *European Journal of Neuroscience* 26(3): 791-799. [This article provides evidence suggesting that a cultural factor, literacy, influences the functional hemispheric balance in reading and verbal working memory-related regions.]

Pica P., Lemer C., Izard V., Dehaene S. 2004. Exact and Approximate Arithmetic in an Amazonian Indigene Group. *Science* 306: 499-503. [This article discusses the following questions: is calculation possible without language? Or is the human ability for arithmetic dependent on the language faculty?]

Plailly J., Delon-Martin C., Royet J.P. 2012. Experience induces functional reorganization in brain regions involved in odor imagery in perfumers. *Human Brain Mapping* 33(1): 224-234. [This article shows that the perfumers' expertise is associated with a functional reorganization of key olfactory and memory brain regions, explaining their extraordinary ability to imagine odors and create fragrances.]

Ponce de León M.S., Golovanova L., Doronichev V. *et al.* 2008. Neanderthal brain size at birth provides insights into the evolution of human life history. *Proceedings of the National Academy of Sciences* 105(37): 13764-13768. [This article questions how the required extra amount of human brain growth is achieved and what its implications are for human life history and cognitive development.]

Pontzer H., Brown M. H., Raichlen D A. *et al.* 2016. Metabolic acceleration and the evolution of human brain size and life history. *Nature* 533 : 390-392. [This article shows that an increased metabolic rate, along with changes in energy allocation, was crucial in the evolution of human brain size and life history.]

Pratt G.A. 2015. Is a Cambrian Explosion Coming for Robotics? *Journal of Economic Perspectives* 29(3): 51-60. [This article analyzes the social effects of the explosion in the diversification and applicability of robotics.]

Premo L.S., Hublin J.J. 2009. Culture, population structure, and low genetic diversity in Pleistocene hominins. *Proceedings of the National Academy of Sciences* 106(1): 33-37. [This article discusses the effect of culturally mediated migration on neutral genetic diversity in structured populations.]

Quallo M.M., Price C.J., Ueno K., Asamizuya T., Cheng K., Lemon R.N., Iriki A. 2009. Gray and white matter changes associated with tool-use learning in macaque monkeys. *Proceedings of the National Academy of Sciences* 106(43): 18379-18384. [This article shows significant brain changes in individual trained monkeys exposed to tool-use training for the first time.]

Ramón y Cajal S. 1999. *Advice for a Young Investigator*. Cambridge, MA, London, MIT Press, 176 pp. [This book written by a mythic figure in science covers everything from valuable personality traits for an investigator to social factors conducive to scientific work.]

Rampon C., Tsien J.Z. 2000. Genetic analysis of learning behavior-induced structural plasticity. *Hippocampus* 10(5): 605-609. [This article discusses the experiments examining the relationship between structural plasticity and learning behaviors, using the environmental enrichment paradigm.]

Regier T., Kay P., Khetarpal N. 2007. Color Naming Reflects Optimal Partitions of Color Space. *Proceedings of the National Academy of Sciences* 104(4): 1436-1441. [This article argues that color naming across languages reflects optimal or near-optimal divisions of an irregularly shaped perceptual color space, see "Whorfian perspective" in the glossary.]

Richerson P. J., Boyd R. 2005. *Not by Genes Alone: How Culture Transformed Human Evolution*. Chicago, Chicago U. Press, 342 pp. [This book offers a radical interpretation of human evolution, arguing that our ecological dominance and our singular social systems stem from a psychology uniquely adapted to create complex culture.]

Rieger M., Wagner N. 2016. Polygyny and child health revisited. *Proceedings of the National Academy of Sciences* 113(13): E1769-E1770. [This article discusses Lawson *et al.*'s article (2015, in this bibliography).]

Roberson D., Davidoff J., Davies I.R.L., Shapiro L.R. 2005. Color categories: Evidence for the cultural relativity hypothesis. *Cognitive Psychology* 50: 378-411. [This article provides further evidence of the tight relationship between language and cognition, see "Whorfian perspective" in the glossary.]

Roth T. L., Lubin F. D., Funk A. J., Sweatt J. D. 2009. Lasting Epigenetic Influence of Early-Life Adversity on the *BDNF* Gene. *Biological Psychiatry* 65(9): 760-769. [This article highlights an epigenetic (see glossary) molecular mechanism potentially underlying lifelong and transgenerational perpetuation of changes in gene expression and behavior incited by early abuse and neglect.]

Rowe M. L., Goldin-Meadow S. 2009. Differences in Early Gesture Explain SES Disparities in Child Vocabulary Size at School Entry. *Science* 323: 951-953. [This article shows that differences in early gesture between children from low–socioeconomic status families and children from high–socioeconomic status families help to explain the disparities in vocabulary that children bring with them to school.]

Sapolsky R. M., Share L.J. 2004. A Pacific Culture among Wild Baboons: Its Emergence and Transmission. *PLOS Biology* 2(4): 534-541. [This article shows that a unique less-aggressive suite of behaviors that affects the overall structure and social atmosphere of a wild baboon troop potentially represents an intergenerational transfer of social culture.]

Sawyer K. 2008. *Group Genius: The Creative Power of Collaboration* New York, Basic Books, 288 pp. [This book tears down some of the most popular myths about creativity, revealing that creativity is always collaborative, even when we are alone.]

Schaller M., Norenzayan A., Heine S.J., Yamagishi T., Kameda T. (Eds). 2009. *Evolution, culture and the human mind*. New York, Psychology Press Taylor & Francis Group, 304 pp. [This book integrates evolutionary and cultural perspectives on human psychology.]

Schlaug G., Jäncke L., Huang Y., Staiger J.F. Steinmetz H. 1995. Increased corpus callosum size in musicians. *Neuropsychologia* 33: 1047-1055. [This article shows the effect of musical training before the age of 7 on the development of the corpus callosum.]

Seeman T.E. 1996. Social ties and health: The benefits of social integration. *Annals of Epidemiology* 6: 442-451. [This article shows that individuals' networks of social relationships represent dynamic and complex social systems that affect health outcomes.]

Segall M. H., Campbell D. T., Herskovits M. J. 1966. *The influence of culture on visual perception*. Indianapolis, Bobbs-Merrill Co, 268 pp. [This study in psychology and anthropology discusses the visual perception across the cultures.]

Ségurel L., Martínez-Cruz B., Quintana-Murci L., Balaresque P., Georges M., Hegay T., Aldashev A., Nasyrova F., Jobling M.A., Heyer E., Vitalis R. 2008. Sex-Specific Genetic Structure and Social Organization in Central Asia: Insights from a Multi-Locus Study. *PLoS Genetics* 4(9): e1000200. doi:10.1371/journal.pgen.1000200. [This article suggests that differences in sex-specific migration rates may not be the only cause of contrasting male and female differentiation in humans, and that differences in effective numbers do matter.]

Shafto M. A., Tyler L. K. 2014. Language in the aging brain: The network dynamics of cognitive decline and preservation. *Science* 346: 583-587. [This article reviews recent behavioral and neuroimaging evidence showing that language systems remain largely stable across the life span and that both younger and older adults depend on dynamic neural responses to linguistic demands.]

Shayer M., Ginsburg D. 2009. Thirty years on – a large anti-Flynn effect/ (II): 13- and 14-year-olds. Piagetian tests of formal operations norms 1976–2006/7. *British Journal of Educational Psychology* 79(3): 409-418. [This article discusses the Flynn effect (the increase in intelligence test scores measured in many parts of the world).]

Sheridan K. M., Konopasky A. W., Kirkwood S., Defeyter M. A. 2016. The effects of environment and ownership on children's innovation of tools and tool material selection. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*. 371(1690): doi 10.1098/rstb.2015.0191. [The authors argue that learning environments supporting tool exploration and invention and conveying ownership over materials may encourage successful tool innovation at earlier ages.]

Shermer M. 2015. *The Moral Arc: How Science and Reason Lead Humanity toward Truth, Justice, and Freedom*. New York, Henry Holt and Co, 560 pp. [This book explains how abstract reasoning, rationality, empiricism, scepticism - scientific ways of thinking - have profoundly changed the way we perceive morality and move us ever closer to a more just world.]

Simonson T. S. et al. 2010. Genetic Evidence for High-Altitude Adaptation in Tibet, et al. *Science* 329: 72-75. [This article reports genome-wide scans that reveal positive selection in several regions that contain genes whose products are likely involved in high-altitude adaptation.]

Sloan E. K., Capitanio J. P., Tarara R. P., Mendoza S. P., Mason W. A., Cole S. W. 2007. Social Stress Enhances Sympathetic Innervation of Primate Lymph Nodes: Mechanisms and Implications for Viral Pathogenesis. *The Journal of Neuroscience* 27(33): 8857-8865. [This article reveals a surprising degree of behaviorally induced plasticity in the structure of lymphoid innervation and defines a novel pathway by which social factors can modulate immune response and viral pathogenesis.]

Sol Daniel. 2009. Revisiting the cognitive buffer hypothesis for the evolution of large brains. *Biology Letters* 5(1): 130-133. [This article reports that evidence in birds and mammals is accumulating that a large brain facilitates the construction of novel and altered behavioural patterns and that this ability helps dealing with new ecological challenges more successfully, supporting the cognitive-buffer interpretation of the evolution of large brains.]

Somel M., Franz H., Yan Z. *et al.* 2009, Transcriptional neoteny in the human brain. *Proceedings of the National Academy of Sciences* 106(14): 5743-5748. [This article shows that the brain transcriptome is dramatically remodeled during postnatal development and that developmental changes in the human brain are delayed relative to other primates.]

Sorokowska Agnieszka, Sorokowski Piotr, Hummel Thomas, Huanca Tomas. 2013. Olfaction and Environment: Tsimane' of Bolivian Rainforest Have Lower Threshold of Odor Detection Than Industrialized German People. *PLoS ONE* 8(7): e69203. doi:10.1371/journal.pone.0069203. [This article suggests that differences in olfactory sensitivity seem to be especially salient between industrialized and non-industrialized populations inhabiting different environmental conditions.]

Spitzer M. 2012. *Digitale Demenz: Wie wir uns und unsere Kinder um den Verstand bringen*. Munich, Droemer Knaur, 368 pp. [This book discusses the impact of digital technologies on our cognitive abilities.]

Storm B. C., Stone S. M. 2014. Saving-Enhanced Memory: The Benefits of Saving on the Learning and Remembering of New Information. *Psychological Science* doi : 10.1177/0956797614559285. [This article suggests that saving certain information provides a means to strategically off-load memory onto the environment in order to reduce the extent to which currently unneeded to-be-remembered information interferes with the learning and remembering of other information.]

Sutikna T., Matthew W. T., Michael J. M. *et al.* 2016. Revised stratigraphy and chronology for Homo floresiensis at Liang Bua in Indonesia. *Nature* 532: 366-369. [This report new stratigraphic and chronological evidence that does not support the ages inferred previously for the H. floresiensis.]

Talhelm T., Zhang X., Oishi S. *et al.* 2014. Large-Scale Psychological Differences Within China Explained by Rice Versus Wheat Agriculture. *Science* 344: 603-608. [Cross-cultural psychologists have mostly contrasted East Asia with the West, but this study shows that there are major psychological differences within China.]

Tang Y.Y., Lu Q., Geng X., Stein E. A., Yang Y., Posner M. I. 2010. Short-term meditation induces white matter changes in the anterior cingulate. *Proceedings of the National Academy of Sciences* 107(35): 15649-15652. [This article shows that integrative body–mind training could provide a means for improving self-regulation and perhaps reducing or preventing various mental disorders.]

Tavor I., Jones O. P., Mars R. B., Smith S. M., Behrens T. E., Jbabdi S. 2016. Task-free MRI predicts individual differences in brain activity during task performance. *Science* 352: 216-220. [The authors propose a model that predicts individual differences in brain activity and highlights a coupling between brain connectivity and function that can be captured at the level of individual subjects.]

Thayer Z. M., Non A. L.2015. Anthropology Meets Epigenetics: Current and Future Directions. *American Anthropologist* 117(4): 722-735. [The authors review some of the ways in which epigenetic methods have been successfully incorporated into anthropological and related studies, and they emphasize promising future directions and challenges for the use of epigenetic data across subfields of anthropology (see "Epigenome" in the glossary).]

Thompson B., Kirby S., Smith K. 2016. Culture shapes the evolution of cognition. *Proceedings of the National Academy of Sciences* 113(16): 4530-4535. [According to this article, culture has dramatically shaped the evolution of the human mind, giving us innate predispositions that only weakly constrain our behavior.]

Tishkoff S. A., Reed F.A., Ranciaro A., Voight B.F., Babbitt C.C., Silverman J.S., Powell K., Mortensen H.M., Hirbo J.B., Osman M., Ibrahim M., Omar S.A., Lema G., Nyambo T.B., Ghori J., Bumpstead S., Pritchard J.K., Wray G.A., Deloukas P. 2007. Convergent adaptation of human lactase persistence in Africa and Europe. *Nature Genetics* 39(1): 31-40. [This article provides a marked example of convergent evolution due to strong selective pressure resulting from shared cultural traits—animal domestication and adult milk consumption.]

Tomasello M. 2009. *Why we cooperate*. Cambridge, MIT Press, 232 pp. [In this book, studies of young children and great apes help identify the underlying psychological processes that very likely supported humans' earliest forms of complex collaboration and, ultimately, our unique forms of cultural organization.]

Tomasello M. 2014. *A Natural History of Human Thinking*. Cambridge MA, Harvard University Press, 192 pp. [In this book, the author weaves his twenty years of comparative studies of humans and great apes into a compelling argument that cooperative social interaction is the key to our cognitive uniqueness.]

Tsankova N. M., Berton O., Renthal W., Kumar A., Neve R. L., Nestler E. J. 2006. Sustained hippocampal chromatin regulation in a mouse model of depression and antidepressant action. *Nature Neuroscience* 9: 519-525. [This book underscores an important role for histone remodeling in the pathophysiology and treatment of depression and highlight the therapeutic potential for histone methylation (see glossary) and deacetylation inhibitors in depression.]

Turnbull C. M. 1972. *The Mountain People.* New York, Simon and Schuster, 309 pp. [This book provides an examination of Ik (an ethnic group living in the mountains of northeastern Uganda) culture and practices.]

Uchikawa K., Shinoda H. 1996. Influence of basic color categories on color memory discrimination. *Color Research and Application* 21: 430–439. [This article indicates that color memory is characterized by the color categories, suggesting a color-category mechanism in a higher level of color vision, see "Whorfian perspective" in the glossary.]

Ulijaszek S. J. 2007. Bioculturalism in *Holistic Anthropology. Emergence and Convergence.* Edited by D. Parkin, S. Ulijaszek, pp. 35-40. New York, Oxford: Berghahn Books. [This paper discusses the issue of the convergence between social and natural sciences.]

UNDP & RBAS. 2003. *Arab Human Development. Report 2003. Building A Knowledge Society*. New York, United Nations Publications, XVI + 210 pp. [This report is a strategic vision for creating knowledge societies in the Arab world.]

Uskul A. K., Kitayama S., Nisbett R. E. 2008. Ecocultural basis of cognition: Farmers and fishermen are more holistic than herders. *Proceedings of the National Academy of Sciences* 105(25): 8552-8556. [This article shows that In Turkey's eastern Black Sea region members of farming and fishing communities, which emphasize harmonious social interdependence, exhibited greater holistic tendencies than members of herding communities, which emphasize individual decision making and foster social independence.]

Van Schaik C. P., Ancrenaz M., Borgen G., Galdikas B., Knott C.D., Singleton I., Suzuki A., Utami S.S., Merrill M. 2003. Orangutan Cultures and the Evolution of Material Culture. *Science* 299: 102-105. [This article shows that great-ape cultures exist, and may have done so for at least 14 million years.]

Victora C. G., Horta B. L., de Mola C. L. *et al.* 2015. Association between breastfeeding and intelligence, educational attainment, and income at 30 years of age: a prospective birth cohort study from Brazil. *The Lancet Global Health* 3(4):

e199-e205. [This article shows that breastfeeding is associated with improved performance in intelligence tests 30 years later, and might have an important effect in real life, by increasing educational attainment and income in adulthood.]

Visalberghi E., Haslam M., Spagnoletti N., Fragaszy D. 2013. Use of stone hammer tools and anvils by bearded capuchin monkeys over time and space: construction of an archeological record of tool use. *Journal of Archaeological Science* 40(8): 3222-3232. [This article argues that archeologists should be aware that transported stone materials and artificial durable landscape features may be the result of activity by non-human animals.]

Voigtländer N., Voth H.-J. 2015. Nazi indoctrination and anti-Semitic beliefs in Germany. *Proceedings of the National Academy of Sciences* 112(26): 7931-7936. [This article shows that Germans who grew up under the Nazi regime are much more anti-Semitic than those born before or after that period.]

Watts J. 2002. Tokyo Public health experts concerned about "hikikomori". *The Lancet* 359: 1131. [This article discusses "hikikomori" (acute social withdrawal), a condition that affects around 700,000 Japanese individuals withdrawing from society for years and sometimes decades.]

Weaver I. C. G., Cervoni N., Champagne F.A., D'Alessio A.C., Sharma S., Seckl J.R., Dymov S., Szyf M., Meaney M.J. 2004. Epigenetic programming by maternal behavior. *Nature Neuroscience* 7: 847-854. [This article shows that an epigenomic (see glossary) state of a gene can be established through behavioral programming, and it is potentially reversible.]

Webb A. R., Heller H. T., Benson C. B., Lahav A. 2015. Mother's voice and heartbeat sounds elicit auditory plasticity in the human brain before full gestation. *Proceedings of the National Academy of Sciences* 112(10): 3152-3157. [This article shows that newborns exposed to maternal sounds had a significantly larger auditory cortex bilaterally compared with control newborns receiving standard care.]

Weston E. M., Lister A.M. 2009) Insular dwarfism in hippos and a model for brain size reduction in Homo floresiensis. *Nature* 459: 85-88. [This article challenges current understanding of brain–body allometric relationships in mammals and suggest that the process of dwarfism could in principle explain small brain size, a factor relevant to the interpretation of the small-brained hominin found on the Island of Flores, Indonesia.]

Whiten A. 2001. Tool tests challenge chimpanzees. *Nature* 409: 133. [This article discusses the following question: do apes fail to understand physics, or do we fail to understand them ?]

Whiten A., Goodall J., McGrew W. C. *et al.* 1999. Cultures in chimpanzees. *Nature* 399: 682-685. [This article presents a systematic synthesis of cultural variation in chimpanzees (*Pan troglodytes*).]

Whybrow P. C. 2015. *The Well-Tuned Brain. Neuroscience and the Life Well Lived*. Norton, New York, 400 pp. [This book is a prescription for genuine human progress.]

Willey J. Z., Gardener H., Caunca M. *et al.* 2016. Leisure-time physical activity associates with cognitive decline: The Northern Manhattan Study. *Neurology* 86 : 1-7. [This article shows that a low level of leisure-time physical activity is independently associated with greater decline in cognitive performance over time across domains.]

Wilson M. 2010. The re-tooled mind: how culture re-engineers cognition. *SCAN* 5:80-187 doi:10.1093/scan/nsp054. [While much fruitful work has focused on how culture influences the contents of cognition, this article argues that culture can in addition exercise a profound effect on the *how* of cognition: the mechanisms by which cognitive tasks get done.]

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Biographical Sketch

Joël Candau is Professor Exceptional class in the Department of Anthropology, and in the Laboratory of Cognitive and Social Anthropology and Psychology (LAPCOS, EA 7278), University of Nice Sophia Antipolis. He is member (elected) of the CNRS National Committee, section 38; Member of the Scientific Council of the GDR 3713 - CNRS (https://gdro3.wordpress.com). After several years of research about various forms of shared memory (real or imaginary: collective memory, familial memory, etc.), his current research is focused on three topics: Sensorial and cognitive anthropology, Anthropology of cooperation, Naturalistic approaches in Social Sciences. J. Candau is currently PI of the ANR COLOSTRUM (http://colostrum.hypotheses.org/). He is the author of over a hundred publications, including the following books: Candau J. 2013. *Antropologia da Memória*. Lisboa, Instituto Piaget; Candau J., Le Gonidec M.-B. (éds.). 2013. *« Paysages sensoriels ». Essai d'anthropologie de la construction et de la perception de l'environnement sonore*. Paris, CTHS; Candau J., Barthélemy T. (eds). 2012. *Mémoire familiale, objets et économies affectives*. Paris, CTHS; Candau J. 2011. *Memória e Identidade*. São Paulo, Editora Contexto; Candau J. (ed.). 2009. *Temps en partage : ressources, représentations, processus*. Paris, CTHS; Candau J. 2005. *Anthropologie de la mémoire*. Paris, Armand Colin; Candau J. 2002. *La memoria e l'identità*. Napoli, *Iper*medium libri; Candau J. 2002. *Antropología de la memoria*. Buenos Aires, Ediciones Nueva Visión; Candau J. 2001. Антропология на паметта. Ed. Odri; Candau J. 2001. *Memoria e identidad*. Buenos Aires, Ediciones Del Sol; Candau J. 2000. *Mémoire et expériences olfactives. Anthropologie d'un savoir-faire sensoriel*. Paris, PUF; Candau J. 1998. *Mémoire et identité*. Paris, PUF; Candau J. 1996. *Anthropologie de la mémoire*. Paris, PUF